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ART. I.—*Brief Contributions to Zoölogy, from the Museum of Yale College.* No. XXIII.—*Results of Recent Dredging Expeditions on the Coast of New England;* by A. E. VERRILL.

DURING the past summer Prof. S. F. Baird, U. S. Fish Commissioner, established his headquarters at Eastport, Me., for the purpose of investigating the fishes and fisheries of the Bay of Fundy and the adjacent waters. In addition to the investigations more immediately connected with the purposes of the Commission, Prof. Baird thought it very desirable that a general zoölogical survey, as complete as possible, should be made of the waters of that region.* He accordingly invited the writer, who had already devoted a large portion of six summers to dredging in those waters, to organize parties and construct the apparatus necessary for accomplishing this plan. It ought, perhaps, to be stated that all the persons engaged in these explorations were

* A similar exploration of the waters of Vineyard Sound, Buzzard's Bay and adjacent localities, during the entire summer of 1871, was conducted by the writer and Mr. S. I. Smith, with the aid of several other scientific gentlemen, under the auspices of the Fish Commission. A brief notice of the results of that exploration may be found in this Journal, vol. ii, page 351. A full and well-illustrated official report will soon be published. Like numerous other naturalists, Mr. J. Gwyn Jeffreys, of England, was a guest of the Fish Commission for about two weeks, and by invitation accompanied our parties on a few dredging excursions. It is to these excursions that he alludes in a recent article on "The Mollusca of Europe compared with those of Eastern North America," published in the Annals and Magazine of Natural History, vol. x, page 237, when he says that "he had dredged last autumn on the coast of New England in a steamer provided by the government of the United States." A more explicit statement would have prevented the disagreeable comments which have recently appeared in some of our newspapers from persons unacquainted with the facts.

volunteers, the funds at the disposal of the Commission being no more than sufficient to pay for the necessary apparatus and materials required for the purpose. Very essential aid was also rendered by the officers of the U. S. Coast Survey by accommodating one party on the steamer Bache, while engaged in the survey of St. George's Bank, and giving them opportunities for dredging in that region; and by the Secretary of the Treasury, who allowed the U. S. revenue cutter Mosswood to take our parties to distant localities and aid in the dredging and other investigations. Much of the success in the explorations of the deeper waters is due to the interest which Capt. Hodgdon and the other officers of the Mosswood took in our investigations, and to the aid which they rendered us in many ways.

According to the plans adopted these explorations had in view several distinct purposes, all more or less connected with the investigation of the fisheries. The special subjects attended to by this section of the Fish Commission party were chiefly the following:

1st. The exploration of the shores and shallow water for the purpose of making collections of all the algæ and marine animals living between tides, on every different kind of shore, including the numerous burrowing worms and crustacea, and to ascertain as much as possible concerning their habits, relative abundance, stations, etc.

2d. The extension of similar observations by means of the dredge, trawl, tangles, and other instruments, into all depths down to the deepest waters of the Bay of Fundy, and to make a systematic survey, as complete as possible, of all the smaller bays and harbors within our reach, both to obtain complete collections of the animals and plants and to ascertain the precise character of the bottom, special attention being paid to localities known to be the feeding grounds of valuable fishes, and to those animals upon which they are known to feed. It is believed that when the collections and notes made by the writer and his associates during previous years shall have been combined with those made during the past season, we shall have a tolerably thorough knowledge of the physical character and life of the bottom and shores in this region.

3d. The depth of the water and its temperature, both at the surface and bottom, was to be observed and recorded in as many localities as possible, and especially where dredging was to be done, and lists of the animals and plants from special localities or depths were to be prepared, so as to show the influence of temperature and other physical features upon animal and vegetable life. Many valuable observations of this kind were made. The temperature of the water was taken in numerous localities, both by Professor Baird and the dredging parties, by means of

the Casella self-registering thermometers, made for this purpose and imported by Professor Baird for this expedition. These were tested by comparisons with a standard instrument.*

4th. The life of the surface waters was to be investigated by means of hand-nets and towing-nets, on every possible occasion, and at all hours. Towing-nets of different sizes, made of strong embroidery canvas, and attached to stout brass rings, were used with excellent results, but very many interesting things were obtained by hand-nets skillfully used. The surface collections made by Messrs. S. I. Smith and O. Harger in the edge of the Gulf Stream, off St. George's Bank, were of the greatest interest, and added a large number of new species to our fauna.

5th. The collections obtained were to be preserved by the best methods: 1st, for the purpose of making a more thorough study of them than could usually be done at the time, and for the purpose of insuring accuracy in their identification, and fullness in the special lists, for the final reports; and, 2d, in order to supply the Smithsonian Institution, Yale College Museum, and a number of other public museums, both American and foreign, with sets of the specimens collected. For this last purpose large quantities of duplicates were collected and preserved, and will be distributed at an early day. The alcoholic collection filled over 2,000 bottles and jars and several large cans.

6th. Those species of animals which cannot be preserved in good condition for study were to be examined with care and minutely described while living. The colors and appearance of the soft parts of other species were to be described in the same way, and also the eggs and young of all kinds.

The notes of this kind already made, chiefly by the writer and Mr. S. I. Smith, amount to more than 1,000 pages; but as we had done this in previous years for large numbers of the species, our attention was largely directed during the past season to special points and to the new and rare forms constantly obtained.

7th. It was regarded as of the utmost importance to secure accurate drawings of the living animals, and especially of such as greatly change their form and appearance when preserved, such as worms, naked mollusks, ascidians, polyps, etc. Accordingly, Mr. J. H. Emerton of Salem was employed during the

* Experience during the past summer has shown that these instruments are not always reliable, especially after they have been used several times in deep water. They should, therefore, be frequently compared with a standard instrument and with each other where several are used, and the error, if any, recorded for each instrument, from time to time, so that its readings may be corrected. Every instrument should be numbered or lettered, and with every observation recorded there should be a designation of the particular instrument used, otherwise errors of several degrees may occur.

month of August to make such drawings. During this time he labored most faithfully and diligently, and with remarkable results, for to his great skill with the pencil he adds the accurate observation and enthusiasm of a genuine naturalist. During the short time he was with us he made 164 drawings from living animals, many of them quite elaborate. All of these were compared critically with the living specimens at the time, and carefully corrected, even in the minute details, whenever necessary. These drawings will be used for the illustration of the final report, and will be of themselves an exceedingly valuable contribution to science, for they nearly all represent animals never before accurately figured, if at all. A large part of them are also of direct importance, since they represent the natural food of our common edible fishes.

8th. In all these investigations the relations existing between the fishes and the lower animals which serve as food for them, were constantly borne in mind, and all information bearing directly upon this subject that could be obtained was recorded. To this end large numbers of stomachs from fishes newly caught were examined, and lists of the species found in them were made. Most of those thus ascertained to be their ordinary food, were traced to their natural haunts from whence the fishes obtain them.

9th. The parasites of fishes, both external and internal, were collected and preserved for future study.

10th. Similar investigations, so far as practicable, were to be carried on at St. George's Bank, on the U. S. steamer Bache, in connection with the ordinary work of the U. S. Coast Survey, by a party of two, provided with all the apparatus and materials necessary for the purpose. This party at first consisted of Mr. S. I. Smith and Mr. Oscar Harger, assistants in the Yale College Museum, both of whom had previously had experience in such work. During the last cruise of the Bache they were relieved by Dr. A. S. Packard and Mr. Caleb Cooke, of Salem. Very important collections were made by both these parties, notwithstanding the unfavorable weather which they encountered.

As a general summary of the character of our collections, I may state that those made this year, together with those obtained by our parties in the same localities in previous years, but not yet reported upon, have added at least 350 species to those hitherto recorded from the same region, exclusive of Foraminifera, Entomostraca, and other minute forms. Many of these are undescribed species, but the majority are known from northern Europe. Of Polyps there were previously known 8 Actinoids and 4 Alcyonoids; we have added 4 Actinoids and 3 Alcyonoids; among the former a new and gigantic species of

Cerianthus,* *Urticina digitata* (Müll.), and *Bolocera Tuediæ* Gosse; and among the latter a *Pennatula*† near to or identical with *P. phosphorea*, a *Virgularia* near *V. mirabilis*, and a creeping species near *Cornularia*. Of Acalephs, Mr. A. Agassiz in his Catalogue of North American Acalephæ gives 48 species as known from this region; to this number we have been able to add 38 species. Of Echinoderms there have been 25 species recorded; to these we have added 10 species, including 4 Asterioids, 1 Echinoid, and 4 Holothurians; among the most interesting of these Echinoderms are *Schizaster fragilis* (Dub. and K.), obtained at five different localities, in 85 to 430 fathoms, both in the Bay of Fundy and at St. George's Bank; *Solaster furcifer* Dub. and K., *Astropecten arcticus* Sars, both from 150 fathoms, near St. George's Bank; *Pentacta assimilis* (D. and K.) and *Lophothuria squamata* (Müll. sp.) both from 430 fathoms. Of Mollusca, Dr. Stimpson enumerated 142 species in his work on the Invertebrata of Grand Menan; to this list we have added at least 95 species, including 30 of Bryozoa, 18 of Ascidians, 13 of Lamellibranchs, 30 of Gasteropods, 3 of Cephalopods. Among the most interesting of these is a fine species of *Octopus*,‡ which we obtained

* *Cerianthus borealis*, sp. nov.

Body much elongated, tapering gradually to the abactinal opening, the surface smooth but more or less sulcated longitudinally. Marginal tentacles very numerous and unequal, the inner ones longest, in the largest specimens 2·25 inches long, and ·12 in diameter at base, gradually tapering, acute; the outer ones 1 inch and less in length. Oral tentacles numerous, crowded in several rows, in the largest specimens about 1 inch long, slender, acute. Color of body dark chestnut-brown, pale bluish just below the tentacles; disk pale yellowish-brown; space within the oral tentacles, around the mouth, deep brown, with lighter radiating lines; oral tentacles pale chestnut-brown; marginal ones deep salmon or light yellowish-brown, the longest barred transversely with six to eight dark reddish-brown spots, each spot partially divided along the median line into two lateral ones.

The two largest specimens, dredged in 28 fathoms, east of Grand Menan, by the writer, measured 5 inches across the disk and tentacles, but their bodies were mutilated. Entire ones of much smaller size were dredged by Dr. Packard and Mr. Cooke in 110 and 150 fathoms, soft mud, near St. George's Bank. The largest of these was 8 inches long, and like other species of the genus, inhabited a thick, tough, felt-like, muddy tube.

† This *Pennatula*, dredged by Dr. Packard and Mr. Cooke in 110 and 150 fathoms, near St. George's Bank, is apparently identical with the species dredged by Mr. J. F. Whiteaves at several localities in the Gulf of St. Lawrence in deep water, both in 1871 and 1872, but resembles ordinary European specimens of *P. phosphorea* more than do the larger specimens sent to me by Mr. Whiteaves. It will require more time and study than has yet been devoted to it to ascertain whether it be a distinct species. A *Virgularia* was also dredged last summer by Mr. Whiteaves, which may be identical with the one dredged by Dr. Packard in 150 fathoms.

‡ *Octopus Bairdii*, sp. nov. (male alone observed). Body short, thick, somewhat depressed, broadly rounded posteriorly, separated from the head only by a slight constriction at the sides. Head almost as broad as the body, swollen above and around the eyes, concave in the middle above; around the eyes, and especially in front and above, there are numerous small conical, often irregular and rough tubercles; and a little removed from the upper side of each eye is a much larger, rough, irregularly conical, erectile tubercle, which has some small, more or less prominent, conical tubercles on its surface; the whole upper surface of the body,

from five different localities in the Bay of Fundy, at depths varying from 60 to 106 fathoms; *Trophon Gunneri* Lov.; *Ringicula nitida* V. (new sp.); *Pleurotomella Packardii* V. (sp. and gen. new), a reddish shell with a deep slit in the outer lip; the adult of *Scaphander puncto-striatus*, over an inch long; *Arca pectunculoides; Pecten pustulosus* V. (new sp.); *Glandula arenicola* V.; *Hornerea lichenoides; Defrancia lucernaria; Anarthropora borealis; Cellaria fistulosa*, etc.: all those last named were from deep water near St. George's Bank, but the *Trophon*, *Arca*, and *Cellaria* were also from the Bay of Fundy, off Grand Menan. Of Worms Dr. Stimpson enumerated 52 species, but we can easily add 125 species to his list. Among the more interesting of these are species of *Tomompteris*, *Sagitta*, *Chætoderma*, *Thalassema* (a small bright green species), *Priapulus*, *Hermione*, *Gattiola*, *Goniada*, *Scalibregma*, *Travisia*, *Ammotrypane*, *Maldane*, *Ammochares*, *Ampharete*, *Amphicteis*, *Melinna*, *Amage*, *Pista*, *Terebellides*, *Aph-*

head, and arms is also covered with minute scattered tubercles, which are usually but little prominent. Siphon large, tapering, capable of being bent in all directions, so as to be used for swimming both forward, backward, and sideways, according to its direction. Arms subequal, relatively short, stout, tapering to slender points, connected for about one third of their length by a web, which extends as a narrow membrane along their margins to near the ends. Suckers small, not crowded, alternating pretty regularly in the two rows; the arms of the first pair each have about 65 suckers; those of the fourth pair about 60. The right arm of the third pair has its terminal portion, for about a third of its entire length, modified for reproductive purposes into a large spoon-shaped organ, broadly elliptical in outline, with the sides incurved, somewhat trilobed at the end, deeply concave within, where there are 9 or 10 elevated transverse folds; at the base there is a fold bent into an acute angle, the apex directed forward, leaving a deep V-shaped sinus behind it, which is in continuation with a shallow groove formed by a thickening of the web along the side of the arm and terminating midway between it and the fourth arm; at the end, the arm terminates in a small conical tip, between the two broadly rounded lobes of the spoon-shaped organ; at the base of this organ there is a slight constriction, below which the basal portion bears about 31 suckers, like those on the other arms. The modified portion of the arm is considerably longer than the distance between the constriction at its base and the interbrachial web, and equal to one half the total length of the part which bears suckers. The corresponding arm on the left side is of the ordinary form and has about 51 suckers. Length of the largest specimen, in alcohol, exclusive of the arms, 1·75 inches; breadth of the body 1·25; between eyes ·7; length of the arms of the first pair, from mouth, 2·25; from mouth to edge of the web ·70; length of modified portion of third right arm ·70; breadth of this organ when expanded ·45.

When living the color was usually pale bluish-white, thickly specked with light orange brown and dark brown. Off Head Harbor, Campo Bello I., in 75 and 80 fathoms, shelly; off Herring Cove in 60 fathoms, muddy; off Grand Menan in 106 fathoms, gravel and sand.

I first dredged this interesting species while on the "Mosswood" in company with Professor Baird, in honor of whom I have named it. It was kept alive several days, and Mr. Emerton made some excellent drawings of it while living. It is somewhat related to *O. Grœnlandicus* Dewh., but the male of the latter has the third right arm much longer, with the modified portion relatively very much smaller and quite different in form, and with more numerous folds, and the basal part bears 41 to 43 suckers: the other arms also have more numerous suckers; the web is less extensive and the body is more elongated.

lebina, etc. Of Crustacea* Dr. Stimpson mentions 65 species, in the work referred to, and has added others in later papers; we have obtained, exclusive of Entomostraca, about 100 species not mentioned by him or other writers as found in this region, including 9 Decapods, 7 Schizopods, and a large number of interesting Amphipods. Among the most interesting are *Hippolyte polaris* and *H. Phippsii* (making 7 species in all); *Caridion Gordoni* Goes, from Eastport and the Bay of Fundy; *Sabinea septemcarinata* (Sabine) and *Stegocephalus ampulla* Bell, from St. George's Bank, etc. A large number of sponges, some of them of special interest, were also obtained.

Of the Algæ several thousand specimens were collected in the Bay of Fundy, representing about 65 species. These were collected and prepared chiefly by Professor Eaton, Mr. Prudden, Mr. Isham, and Mrs. Verrill. Some species were obtained which are new to the flora of our coast, among them *Laminaria dermatodea*, which was found in abundance near Eastport, at low water and also in 20 fathoms. Interesting observations on the range in depth of some of the algæ were also made. Growing specimens of *Delesseria sinuosa*, attached to Ascidians, were dredged in 75 and 80 fathoms, and were also found abundantly at various depths from low water down to 40 fathoms; *Ptilota serrata* occurred in 75 fathoms, and was also abundant at all depths less than 40 fathoms, up to low water mark, wherever the bottom was rocky. Other species occurred in depths of 20 to 50 fathoms.

The operations in the Bay of Fundy and in the bays near Eastport, were mostly under the immediate superintendence of the writer, whose party was located at Eastport. This party was quite variable in numbers, but usually consisted of at least eight or ten persons, part of whom were naturalists of considerable experience in such researches. There were twenty-five persons in all who took part in this work. Among those who were particularly useful and devoted to the work, Mr. S. I. Smith and Mr. Oscar Harger, of New Haven, who were with our party previous to their expedition to St. George's Bank in the Bache; Prof. J. E. Todd, of Tabor, Iowa; Mr. T. H. Prudden and Mr. George W. Hawes, assistants in the Sheffield Scientific School; Mr. J. B. Isham, of New Haven; Mr. J. K. Thacher, of New Haven; Mr. J. H. Emerton, of Salem; and Mr. G. Brown Goode, of Middletown, should be specially mentioned. Prof. D. C. Eaton, of New Haven, was with us a short time to collect the algæ, and many others who were able to remain only for a short time rendered important aid.

* All the Crustacea have been put into the hands of Mr. S. I. Smith, and to him I am indebted for the identification of most of the species referred to in this paper. Mr. O. Harger has, however, consented to determine and describe the Isopods.

A small party, consisting of Prof. H. E. Webster and Mr. Chas. Pond, of Union College, were located for a short time at Grand Menan, and made some very important collections there, both at low water and by dredging. The large lots of "sea-oranges" (*Lophothuria Fabricii* V.), *Pecten tenuicostatus*, *Mactra polynema* (St.), *Doris sulphurea*, and of *Lucernarians*, including four species, collected by them, were particularly fine. They also obtained collections of special value, because collected at the same localities where the lamented Dr. Stimpson dredged, in 1850, the specimens described in his well known work on the Invertebrata of Grand Menan. Prof. Webster and Mr. Pond had, earlier in the season, carried on extensive dredgings off Cape Porpoise, near the western extremity of the coast of Maine, at various depths down to 40 fathoms, in behalf of Union College, and obtained there an interesting collection.

Messrs. S. I. Smith and Oscar Harger were delegated to accompany the Bache to explore the St. George's Banks, but owing to various delays in the departure of the steamer they did not actually get off until the last of August, consequently the time for the operations was very much shortened and the weather was for the most part rough and stormy. They succeeded, however, in obtaining ten casts which proved to be of great interest. They made one successful dredging in 430 fathoms, which is the deepest yet done on the American coast, north of Florida.* From this single haul in 430 fathoms they obtained 44 species of animals, exclusive of Foraminifera. Among them were representatives of most of the classes of invertebrate marine animals. Some of them are of great interest and many of them quite new to American waters, although previously described from the European coast. The lines of soundings and dredgings run by the Bache were located by accurate observations, and will be reported upon hereafter, the soundings and temperature determinations being a part of the regular work of the officers of the Coast Survey. The deepest dredging (g) referred to above, was made on Sept. 15th, in N. lat. 41° 25′, W. long. 65° 42·3′; temperature of the air 66° F.; of the surface water 65°; of the bottom water 51° (the latter probably subject to considerable correction for error of the instruments).† Among the more interesting things obtained in this locality were the following, which are new to the U. S. coast, or at least have not been previously recorded :‡ *Urticina*

* Several dredgings were made by Pourtalés, off Florida, in 450 to 600 fathoms.

† The character of the life at this locality was very similar to that prevailing in the deepest waters of the Bay of Fundy, where we found the temperature in 80 to 106 fathoms to be from 37·5° to 40°. Many of the species were identical from the two regions, and eminently arctic in character.

‡ Several of these were also dredged by our parties in the deepest waters of the Bay of Fundy, and subsequently by Dr. Packard and Mr. Cooke.

digitata (Müll. sp.); *Pentacta assimilis* (Dub. and Koren sp.); *Lophothuria squamata* V. (Müll. sp.); *Schizaster fragilis* (D. and K. sp.); *Campanularia verticillata*; *Lafoëa fruticosa* Sars.; *Calycella fastigiata* Hincks (var. with long pedicels); *Sertularella Gayi* H.; a new species of *Halecium*;* *Pecten pustulosus* V. (new sp.): *Astarte* sp. (the same as "*A. sulcata, var. minor*," recorded by Whiteaves from deep water in the Gulf of St. Lawrence, but perhaps an obese and dwarf variety of *A. lens*), *Rhynchobolus setosus* (Œrst. sp.); *Scalpellum* sp., etc. In addition to these there were several species known previously from deep water, such as *Epizoanthus Americanus* V.; *Ophioglypha Sarsii*; *Cryptodon obesus* V.; *Bela cancellata*. But the majority of the species are well known inhabitants of the shallow waters of New England, some of them even reaching low-water mark. Among these are *Urticina crassicornis*; *Tubularia indivisa*; *Eudendrium ramosum*; *Sertularella tricuspidata* Gray; *Euryechinus Dröbachiensis* V.; *Echinarachnius parma*; *Margarita obscura*; *Natica clausa*; *Mamma immaculata*; *Lunatia Grönlandica*; *Neptunea pygmæa*; *Entalis striolata*; *Leodice vivida* (St.); *Nothria conchylega* Malm. (abundant), *Pycnogonum pelagicum* St.; *Melita dentata* Boeck; *Unciola irrorata* Say; *Pandalus annulicornis*; *Eupagurus Kroyeri* St., etc.

The bottom was composed of coarse gravel and sand, and the specimens obtained indicate a rich and varied fauna, while the presence of a large number of predacious species, with well developed eyes, shows that there must be plenty of light.

They also obtained many very interesting things from various localities on and near St. George's Bank, and Le Have Bank, off Nova Scotia. On St. George's Bank, in N. lat. 41° 25′, W. long. 65° 50.3′, in 60 fathoms (e), a large quantity of Hydroids were obtained. Among them were several species new to the American coast, viz., *Gonothyrea hyalina* Hincks; *Campanularia Hincksii* Alder; *Coppinia arcta* Hincks; and a new species of *Diphasia*,† remarkable for having the hydra cells

* *Halecium robustum*, sp. nov. Stem stout and coarse, composed of many tubes; branches stout, tapering, compound except at tips, pinnately or bipinnately branched, the branchlets spreading at an angle of about 45°; yellowish white and translucent, about ·5 of an inch long, divided by simple distant constrictions, the long internodes usually bearing from two to four hydroids. Hydrothecæ alternate, large, deep, somewhat vase-shaped, with an even, slightly everted rim, below which there is a slight constriction; the middle region is slightly smaller, gradually narrowed toward the base, with a simple diaphragm near the base within. The hydrothecæ are articulated upon slightly prominent projections from the stem, in an oblique and excentric position so as to produce a decidedly geniculated appearance. Most of the hydrothecæ are simple, but some have one or two slightly prominent secondary rims near the margin. Height about four inches.

† *Diphasia mirabilis*, sp. nov. Stem stout, rather rigid, narrowed at base, pinnately branched, somewhat flexuous between the branches, which are alternate, stout, rigid, straight, constricted at base, spreading at an angle of about 45°. Hydrothecæ on the main stem in two rows, nearly opposite; on the branches

arranged in six rows along the branches, instead of two opposite rows.

Many other interesting species occurred here, among them *Epizoanthus Americanus* V., *Cellaria fistulosa* Linn., *Stylifer Stimpsonii* V. (on *Euryechinus Dröbachiensis*), *Acirsa borealis*, *Amauropsis helicoides*, *Sabinea septemcarinata* (Sabine).

At another locality (d), a few miles from this, in N. lat. 41° 25′, W. long. 66° 25′, in 50 fathoms, sandy and shelly bottom, temperature at bottom 45°, surface 62°, Aug. 31st, a similar assemblage of species occurred. The Hydroids and Bryozoa were very numerous. Among the former the most abundant were *Hydrallmania falcata* Hincks, *Sertularia cupressina* Linn., *Diphasia fallax* Ag., *Sertularella polyzonias* Gray (var. *robusta*), *S. tricuspidata* Hincks, *Lafoëa dumosa* Sars, and *Campanularia verticillata;* but *Lafoëa fruticosa* Sars, *Campanularia Hincksii*, *C. volubilis* Alder, +*Halecium Beanii* Johns., *Calycella syringa* Hincks, *Cuspidella humilis* Hincks, *Eudendrium ramosum* Ehr., and *Tubularia indivisa* Linn., also occurred. Among the Bryozoa the most abundant were *Cellularia ternata* Johns., *C. ternata, var. duplex* Smitt, *Bugula Murrayana* Busk, *Cellepora scabra, var. plicata* Smitt, *C. avicularis* Hincks, and *Discopora Skenei* Smitt (*? var.*), the last three investing the stems of Hydroids in profusion; *Cellaria fistulosa* L., *Carberea Ellisii* Smitt, and *Farrella familiaris* (Gros. sp. = *F. pedicellata* Alder), also occurred. The Hydroids and Bryozoa from this and other localities were covered with immense numbers of Foraminifera.

At another locality (c), west of the last, in 28 fathoms, coarser sand, *Glandula arenicola* V. occurred in great abundance, associated with the ordinary sand-dwelling Mollusca. This species of Ascidian had been known before only from a few specimens dredged in Murray Bay, Can., by Dr. Dawson, and off Martha's Vineyard, by Mr. Prudden.

Off Cape Sable, N. lat. 43° 20′, W. long. 65° 21′, at the depth of 45 fathoms, the temperature of the bottom was found to be 35°, the surface being 56°, and the air 58°; upon Le Have Bank (h), N. lat. 42° 56′, W. long. 64° 51′, in 45 fathoms, the temperature of the bottom was found to be 36°, of the surface 61°, on Sept. 12. These were the lowest temperatures observed during the summer.* In accordance with these temperatures

mostly in six regular rows, occupying all sides of the branches, those in the adjacent rows alternating. The hydrothecæ have large, appressed, somewhat swollen bases, but the upper portion is rapidly narrowed, prominent and curved outward; aperture strongly bilabiate, operculated. Reproductive capsules not observed.

* The lowest temperature observed in the Bay of Fundy was 37·5°, in 106 fathoms, east of Grand Menan, in the center of the bay. At the depth of 945 fathoms, in N. lat. 42° 18′, W. long. 64° 05′, the temperature, taken by the officers of the Bache were 62° at the surface (air 63°), and 37° at the bottom. At the depth of 1,029 fathoms, N. lat. 42° 14′, W. long. 63° 59′, they found the surface temperature 63° and the bottom 39°. N. lat. 41° 53′, W. long. 65° 6′, in 1,300

the animal life in this region was found to have a more arctic character than in most of the other localities examined.*

Among the arctic species found here were *Thuaria articulata*, *Rhynchonella psittacea*, *Astarte elliptica*, *A. Banksii*, *Scalaria Grœnlandica*, *Aporrhais occidentalis*, *Trophon Gunneri*, *Bela violacea*, and many other northern shells; *Pteraster militaris*, *Lophothuria Fabricii* V., *Eupagurus Kroyeri* St., *Paramphithoe cataphracta* (Stimp.), *Tritropis aculeatus* Boeck; *Myriozoum subgracile*, *Eschara papposa* Pack. and *Escharoides rosacea* Smitt. The last four and the four first named were not found in any of our Bay of Fundy dredgings, and have not been found so far south before, to my knowledge. In 60 fathoms (i), near the last locality, N. lat. 42° 44′, W. long. 64° 36′, a similar assemblage of animals was met with, including the *Tritropis aculeatus*, but there were a number of additional ones of interest, among them *Acanthozone cuspidatus* Boeck, *Sabinea septemcarinata* (Sabine), *Hyas araneus*, *Turritella reticulata*, *Aglaophenia myriophyllum*, *Lafoëa fruticosa* Sars, and a peculiar sponge (*Polymastia*), growing in short stump-like masses, with a convex and verrucose summit, looking something like fragments of cauliflower. The temperature at this place was not ascertained, owing to the loss of the thermometer.

Near the entrance to Halifax harbor, off Chebucto Head, in 20 fathoms, on a bottom of soft mud and sand (j), some interesting species were dredged, and the fauna was found to be more arctic in character than even that of Grand Menan. Among the species found here were *Hyas araneus*, *Halirages fulvocinctus* Boeck, *Aporrhais occidentalis*, *Turritella reticulata*, *Margarita varicosa*, *Astarte elliptica*, *Macoma proxima*, *Thracia myopsis*, *Rhynchonella psittacea*, etc. The temperature was not ascertained at this locality.

Among the several interesting collections made by Messrs. Smith and Harger, perhaps none are of more interest and novelty than those obtained by surface nets in the vicinity of St. George's bank, but evidently within the inner limits of the Gulf Stream, as situated at that particular date. These collections were mostly made during two days (Sept. 14th and 15th), and the weather was not very favorable for that kind of work, but the results were highly gratifying. The best localities were (l) in N. lat. 42° 3′, W. long. 63° 49′, where the temperature

fathoms, muddy bottom, the temperature was 39°, with the surface 57°, but in N. lat. 42° 21′, W. long. 64° 9′, the temperature of the bottom in 1,120 fathoms was found to be 44°, the surface and air being 62°. It is greatly to be regretted that no dredgings could be made in any of these deeper waters.

* It is somewhat remarkable that *Crepidula unguiformis* Lam. (*plana* Say), a southern species, occurred both here and on St. George's Bank, although unknown in the Bay of Fundy. This is a species perfectly distinct from *C. fornicata*, with which some writers have united it. Frequently it occurs associated with the latter on the *outside* of shells, *Limuli*, etc.

of the surface was 72°; and (n) in N. lat. 41° 25′, W. long. 65° to 65° 25′, where the temperature varied at different hours from 66° to 70°.

Among the species obtained here were *Neptunus Sayi* Stimp., *Nautilograpsus minutus* Edw., *Latreutes ensiferus* Stimp., *Lucifer*, *Mysis*, *Thysanopoda*, *Calliopeus leviusculus*, *Hyperia*, two species, and seven other genera allied to *Hyperia*, all of which are new to the North American coast, viz: *Anchylomera*, *Oxycephalus*, *Platyscelus*, *Thyropus*, *Phrosina*, *Phronima*, *Pronoe;* besides these there were species of *Sapphirina*, *Lepas*, and many other Crustacea. Among the Acalephs were *Stomolophus meleagris* Ag., *Pelagia cyanella* Per. and Les., and *Cestum Veneris* (?) Les., of which the first two have been known before only from far south, on the coasts of Florida and S. Carolina, and the last from the Mediterranean; *Physalia Arethusa* Til., and *Charybdea periphylla* Per. and Les., were also obtained, both of which are properly Gulf Stream species. The latter has apparently been unobserved since it was briefly described in 1809, and very imperfectly figured. Of Mollusca there were *Salpæ* in abundance, three species of *Heteropods* new to our coast, and ten species of *Pteropods*, previously unknown in our waters. Among the latter are *Styliola acus* (Eschscholtz sp.), and four other species of the same genus, two of *Pleuropus*, with species of *Spiralis*, etc. Besides these, *Sagitta* was abundant, also various larval Crustacea, and attached to floating masses of *Fucus vesiculosus* and *Sargassum bacciferum* were species of Hydroids, etc. A small fish (*Motella*) was also taken at the surface.

Dr. A. S. Packard, of Salem, Mass., kindly consented to take charge of the dredging on the last cruise of the Bache, for Messrs. Smith and Harger were obliged to return to New Haven. It ought to be mentioned here, however, that he had long desired to explore the region of St. George's Bank, and had he returned from Europe earlier in the season he would doubtless have gone on the previous cruises. He was assisted by Mr. Caleb Cooke, of Salem, who has had considerable experience in collecting, both on our coast and that of Africa. They sailed on the 12th of October, and although they had but one day favorable for dredging, seven successful hauls were made in depths of 110 (o), 85 (p), 45 (q), 40 (r), and 150 fathoms (s). The first locality was somewhat to the west and north of the eastern end of the bank, in N. lat. 42° 5′, W. long. 67° 49′; the others were made in sequence, going eastward, as the steamer approached and passed over the crest of the bank, near its eastern end; but the last, in 150 fathoms, was a little farther north as well as east from the preceding ones. It will, therefore, be apparent that the region examined on this cruise was quite distant from those explored previously,

and in the three deeper localities the bottom was of fine, soft, sandy mud, which was not the case in any of the previous dredgings. The presence of mud in these localities may, perhaps, be due to the fact that they are in the depression or valley between St. George's Bank and the coasts of Maine and Nova Scotia, and hence sheltered to some extent by the banks from the action of the powerful currents, which sweep over their outer sides and summit, and which appear to be sufficient to prevent the accumulation of fine sediments in that region, even at the depth of 430 fathoms, while in all shallower depths the bottom was wholly of gravel, sand, and shells. At the summit of the banks (St. George's Shoal and Cultivator Shoal) the water is very shallow,—so much so that the waves break there in heavy storms,—and the bottom is composed of moving sands, almost barren of life in some places.

The existence of powerful currents in this region was fully demonstrated this season by the Bache, and their velocity was ascertained in some localities. Mr. Smith also tells me that even far to the eastward of St. George's Bank, where no bottom was found at 1800 fathoms, the conflicting currents were sufficient to produce heavy "rips" which, even in calm weather, roared like a rapid river or like heavy breakers on a beach.

In accordance with the more sheltered positions and the muddy nature of the bottom, the animal life in the three deeper localities examined by Dr. Packard was quite different from that found on the outer side of the banks by Smith and Harger, and by me in the Bay of Fundy, at similar depths. The localities examined in the Bay of Fundy, which most resemble these, are two limited areas of muddy bottom, in depths ranging from 20 to 60 fathoms, to the eastward of Campo Bello I. and Grand Menan, which are doubtless more or less protected by those islands from the very powerful tidal currents of the bay, for in the middle of the bay we found only hard gravelly and pebbly bottoms, often pretty thickly covered with small boulders. The fauna of the deeper parts of the Gulf of St. Lawrence (where the bottom is also of soft mud) which we now know tolerably well, through the investigations of Mr. J. F. Whiteaves during the summers of 1871 and '72, resembles that of Dr. Packard's deepest dredgings much more closely than does any other yet examined. Many species from the two regions are identical and are also unknown from other localities on this side of the Atlantic. The fauna was essentially the same in the three muddy localities explored by Dr. Packard, and referred to above, viz.: in (o) 110, (p) 85, and (s) 150 fathoms; the temperatures of the surface (Oct. 12th), were 56°, 56°, and 52° F., respectively; and of the bottom 49°, 49°, and 52°. These bottom temperatures are doubtless to be corrected for a con-

siderable instrumental error, for which I have no data. The life indicates a temperature not above 40°, and perhaps considerably lower.

As a full report, with complete lists of the species obtained on this and the previous cruises, will soon be published, it is only necessary to mention, at this time, some of the more interesting discoveries.

From the 150-fathom locality, N. lat. 42° 11′, W. long. 67° 17′, 92 species were obtained,* exclusive of Foraminifera.

Among the Radiata from this place, the most important were (u) *Bolocera Tuediæ* Gosse; (u, o) *Cerianthus borealis* V., sp. nov.; (o, p) *Pennatula*; + *Virgularia* (see note, page 5); (g) *Sertularella Gayi* Hincks; *S. tricuspidata* H.; *Sertularia cupressina* Linn.; *Ophioglypha Sarsii* Lym.; *Ophiacantha spinulosa* Müll. and Trosch.; + *Archaster arcticus* Sars; + *Solaster furcifer* Dub. and Koren; (t, g, o, p) *Schizaster fragilis* (D. and K.); *Echinarachnius parma*; + *Thyone fusus?* Koren. Of these the *Virgularia*, *Bolocera*, *Cerianthus*, *Astropecten*, *Solaster*, and *Thyone* have all been added to the American fauna this year, the last three being as yet known on this side of the Atlantic only from Dr. Packard's dredgings.

Of Mollusca there were 32 species: among the Bryozoa were + *Discoporella verrucaria* Smitt; + *Anarthropora borealis* Smitt; + *Hornerea lichenoides* Smitt; *Cellularia ternata* (*var.*) Johnst.; *Bugula Murrayana* Busk: among the Lamellibranchs were (g) *Pecten pustulosus* V., sp. nov.;† (v) *Arca pectunculoides* Scacchi; + *Neæra arctica* Sars; *Yoldia obesa* (Stimp.); *Leda tenuisulcata;*

* In this and the following lists, the letters, o, p, q, etc., indicate that the species so marked, were also found at the localities designated by those letters (see pages 8—10, 12, etc.). The localities following s, are in the Bay of Fundy,—t is in the center of the bay, east of Grand Menan, in 95 to 106 fathoms; u is east of Grand Menan in 28 to 52 fathoms; v is west of the southern portion of Grand Menan in 40 to 60 fathoms; w, is between Campo Bello and the Wolves, in 60 fathoms; x is off Head Harbor, in 70 to 90 fathoms. The sign + indicates that the species has not been found as yet in any other locality on the coast of the United States. Species without any designation have been found in numerous localities.

† *Pecten pustulosus* V., sp. nov.

Upper valve more convex than the lower, a little swollen toward the umbo; length and breadth nearly equal, the margin diverging nearly at right angles from the beak to the middle of the anterior and posterior borders, on each of which there is an obtuse angle, from which the outline of the ventral margin forms a regular curve, nearly semicircular, but a little produced ventrally; the surface with about 14 radiating rows of relatively large, prominent, round, hollow vesicles, those in the middle rows nearly hemispherical, while part of those of the lateral ones are subconical and smaller; seven or eight of the rows are first developed, at a short distance from the apex of the shell, the other ones afterward coming in between the primary ones; the rows are distant in the middle and more crowded together toward the borders; between the rows of vesicles the surface is marked by distant, fine, impressed grooves, which pass between and separate the vesicles; on the umbos, above the origin of the vesicles, the border of the grooves rises into a thin, slightly elevated lamella. Lower valve with fine, close, slightly raised, concentric lamellæ, becoming faint toward the beak. Auricles unequal, that of the

(g, i) *Astarte lens* (dwarf var.); *A. quadrans* Gould: of the Gasteropods some of the more important were +(o) *Pleurotomella Packardii* V.,* a new genus and species, allied in some respects to *Pleurotoma*, but in lacking an operculum related to *Defrancia; Admete viridula; Neptunea pygmæa* Ad.; *Aporrhais occidentalis* Sowerby; *Natica clausa* Brod. and Sowerby; *Lunatia Grönlandica;* +*Torellia vestita* Jeffreys;† *Velutina zonata* Gould; *Margarita obscura; M. cinerea* Couth.; *Scaphander puncto-striatus* H. & A. Ad. (Mighels and Adams, sp. 1841, ?=*S. librarius* Lov., 1846), an adult specimen 1·15 of an inch long, ·75 broad, with a firm, rather thick shell, destitute of epidermis, but with punctate lines

upper valve small, and a little projecting posteriorly, much larger and more prominent, with a deep, curved emargination anteriorly, its surface with concentric lamellæ and radiating rows of small conical vesicles; that of the lower valve with a deep, angular byssal notch anteriorly, its surface with concentric lamellæ and faint radiating ridges. Color yellowish-white. Length ·30 of an inch; height ·32; thickness ·10.

Near St. George's Bank (s), in 150 fathoms, mud (living); east of St. George's (g) in 430 fathoms, sand and gravel (dead, but fresh valves).

* *Pleurotomella Packardii* V., sp. and gen. nov.

Shell thin, fragile, translucent, pale flesh-colored, moderately stout, with an acute, somewhat turreted spine. Whorls nine; the apical whorls, for about two and one half turns, nearly smooth, regular, convex, chestnut-colored; below this the whorls are shouldered, strongly convex in the middle, but with a smooth concave band below the suture, corresponding to the posterior notch in the outer lip; the whorls are crossed below the sub-sutural band by about 16 strong, prominent, rounded, somewhat oblique ribs, most prominent on the middle of the whorl, but not angulated; on the last whorl these ribs become very oblique below the middle, and follow the curve of the edge of the lip, nearly fading out anteriorly; the surface between the ribs is marked by faint lines of growth and by fine, unequal, slightly raised revolving lines, which pass over the ribs without interruption. They become more evident on the lower part of the last whorl, and are very faint on the sub-sutural band, which is more decidedly marked by receding, strongly curved lines of growth. The aperture is rather broad above, elongated below, sub-oval, outer lip very thin, sharp, prominent above, separated from the preceding whorl by a wide and very deep sinus, extending back for about one fifth of the circumference of the whorl; the anterior border of the lip is incurved near the end, and obliquely truncate, forming a short, straight canal. Columella simple, nearly straight, its inner edge toward the end, sharp and obliquely excurved. No operculum. Length ·85 of an inch, breadth ·45, length of aperture ·48, breadth of same ·20. The absence of eyes and operculum, great size of the posterior sinus, and character of the apex, indicate that this shell represents a new genus, which I purpose to call *Pleurotomella*. One living specimen from (o) 110 fathoms.

† *Torellia vestita?* Jeffreys.

This shell in form and size somewhat resembles large specimens of *Margarita helecina*, but it has a ciliated epidermis resembling that of *Velutina haliotoidea*. The spire is small and low; whorls four, the last large, well rounded, forming the bulk of the shell. Suture deep. Umbilicus small and deep, somewhat concealed by the reflected outer edge of the columella, which recedes in front and joins the outer lip at an obtuse angle, forming a broad, shallow, anterior emargination, inner border of the columella a little excavated near the body whorl, slightly swollen in the middle. Outer lip sharp, regularly rounded. Epidermis thick, greenish, with conspicuous lines of growth, finely reticulated by raised revolving lines, along which arise numerous, slender, but short, hair-like processes. Shell beneath the epidermis white, nearly smooth. Length ·30 of an inch, breadth ·40, length of aperture ·24, breadth ·18.

Only one specimen, dead and inhabited by a *Sipunculus*, was found.

as in the smaller specimens previously known; and *Ringicula nitida* V.,* a new species allied to *R. buccinea* Desh., of Europe; *Cylichna alba; Leptochiton albus; Entalis striolata* St.; and *Dentalium occidentale* St., etc.

Among the Crustacea were *Eupagurus Kroyeri* Stimp., *E. Bernhardus* St., *E. pubescens* St., *Hyas coarctatus*, *Ptilocheirus pinguis* Stimp., *Harpina fusiformis* Smith (St. sp.), *Ægа polita* Stimp., *Æ. psora* Bate and West., and *Balanus porcatus*. All of these Crustacea, except the species of *Ægа*, are common in the shallow waters of the Bay of Fundy.

[To be continued.]

ART. II.—*Impressions and Footprints of Aquatic Animals and Imitative Markings, on Carboniferous Rocks;* by J. W. DAWSON, LL.D., F.R.S.

THE footprints and other markings of aquatic invertebrate animals and of fishes are necessarily, for the most part, less distinctive and important than those of land animals, both because less characteristic in themselves, and because reproduced under similar forms in very different geological periods. The former peculiarity has caused them to be neglected as of little importance, or to be confounded with impressions of plants. With reference to the latter, I have myself shown that the impressions made by the modern King-crab faithfully represent the *Protichnites*, *Climactichnites*, and *Rusichnites* of the Primordial and Silurian, and similar comparisons have been made by Salter, Jones, Dana and others, between the tracks of modern Crustaceans and worms and some of those in the oldest rocks.

1. *Protichnites* Owen.

The footprints from the Potsdam Sandstone in Canada, for which this name was proposed by Owen, and which were by him referred to Crustaceans probably resembling *Limulus*, were

* *Ringicula nitida* V., sp. nov.

Shell small, white, smooth, broad oval, with five whorls, spire rapidly and regularly tapered, sub-acute, shorter than the aperture. Whorls very convex, regularly rounded, the sutures well impressed; a well marked, impressed, revolving line just below the suture; the surface otherwise nearly smooth, but with more or less distinct, distant, microscopic revolving lines, most distinct anteriorly. Aperture somewhat crescent-shaped. Outer lip evenly rounded, forming the segment of a circle, the border regularly thickened, receding a little posteriorly, near the suture. Callus on the body whorl narrow, nearly even, but a little swollen in the middle and slightly raised. Columella stout, recurved at the end, with two strong, very prominent, equal, spiral folds,—the anterior one projecting beyond the canal, with the end rounded. Length ·17 of an inch; breadth ·125; length of aperture ·10; breadth of same ·043.

Two living specimens from (o) 110 and (s) 150 fathoms, muddy bottom.

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shown by me in 1862* to correspond precisely with those of the American Limulus (*Polyphemus occidentalis*). I proved by experiment with the modern animal that the recurring series of groups of markings were produced by the toes of the large posterior thoracic feet, the irregular scratches seen in *Protichnites lineatus* by the ordinary feet, and the central furrow by the tail. It was also shown that when the Limulus uses its swimming feet it produces impressions of the character of those named *Climactichnites*, from the same beds which afford *Protichnites*. The principal difference between *Protichnites* and their modern representatives is that the latter have two lateral furrows produced by the sides of the carapace, which are wanting in the former.

As Limuloid crustaceans are well known in the Carboniferous beds of Europe and America, their footprints might be expected to occur in rocks of this age, but the first I have met with were sent to me last summer by my friend Mr. Elder, of Harvard College, who found them quite abundantly in dark-colored flag-stones belonging to the Millstone Grit formation at McKay's Head in Nova Scotia (fig. 1). The animal which produced these marks must have been of small size (about half an inch in breadth), in this agreeing with the usual size of the Coal-formation Limuloids; and like the ancient Protichnite-makers, it left no trace of the edges of the carapace, but a very distinct impression of a sharp pointed tail. Its posterior feet had three or possibly four sharp toes. There were besides several pairs of sharp-pointed walking feet. On the same slabs there are some series of marks, evidently made by the same kind of animal, which have no tail-mark, and there are tail-marks with only traces of those of the toes. It is worthy of notice that, though these tracks indicate the presence of the animals, no crusts of Carboniferous Limuloid crustaceans have yet been found in Nova Scotia. The sand in which the tracks now referred to were made was probably too hard to permit the swimming feet to make any impression. With respect to the absence of the marks of the sides of the carapace, I may observe that the genus *Belinurus* of the Carboniferous had the sides of the carapace less deep than that of the modern Limulus, and this may also have been the case with the more ancient Limuloids of the Potsdam. See as to this a letter by Prof. Hall in the Canadian Naturalist, 1862.

To Protichnites may perhaps be referred a very singular impression from Horton Bluff (fig. 2), which at first sight much resembles *P. Scoticus*, from the Primordial of Roxburghshire, though the Carboniferous specimen is larger and more complicated.† It seems to have been produced by the successive

* Canadian Nat., vol. vii. † Siluria, 4th edition, p. 153.

pressure of a pair of flat organs, crenated or toothed at the edges, rather than divided into separate toes. Its horizon is the Lower Carboniferous. It was collected by Prof. Hartt.

The first species of *Protichnites* referred to above may be appropriately named *P. Carbonarius*, and the second *P. Acadicus*. They are, I believe, the first impressions of this kind found in the Carboniferous.

2. *Rusichnites* Dawson.

In a paper published in the Canadian Naturalist, 1864, I showed that the singular bilobate markings with transverse striæ named *Rusophycus* by Hall, and found in the Chazy of Canada and the Clinton group of New York, are really casts of burrows connected with footprints consisting of a double series of transverse markings, and that a comparison of them with the trails and burrows of Limulus justified the conclusion that they were produced by Trilobites. I proposed for these and for similar impressions of small size found in the Carboniferous, the name given above. The Carboniferous examples I supposed might have been produced by the species of *Phillipsia* found in these beds. A specimen recently obtained from Horton shows this kind of impression passing in places into a kind of Protichnites, as if the creature possessed walking feet as well as the lamellate swimming feet which it ordinarily used.

I can scarcely doubt that the *Cruziana semiplicata* of Salter, and *C. similis* of Billings from the Primordial of Newfoundland, must have been produced by crustaceans not dissimilar from those to which *Rusichnites* belongs.

To *Rusichnites* rather than to Protichnites ought perhaps to be referred certain transverse linear impressions with a broad central groove from the Lower Carboniferous of Horton, which occur at that place under different modifications, and sometimes seem to change into light scratches or touches of feet employed in swimming, or end abruptly as if the animal had suddenly risen from the bottom.

Arenicolites Salter.

This genus may be held to include cylindrical burrows of worms with or without marks of minute setæ. They occur in rocks of all ages, and are especially abundant in the Lower Carboniferous series of Half-way River, Nova Scotia, and in the Upper Coal-formation at Tatamagouche in the same province; those at the latter place showing minute scratches produced by the setæ of the worms.* With the ordinary form at Horton there occur very long and slender, thread-like forms of the same nature with those to which the name *Nemertites* has been given.

* Journal of the Geological Society, vol. ii.

I have long been of opinion that many of the cylindrical markings which have been described as plants under the names *Palæochorda*, *Buthotrephis*, *Palæophycus*, *Arthrophycus*, &c., are burrows of this kind, but the main difficulty seemed to be to account for their branching in a radiate or palmate manner. I have recently met with specimens from the Primordial and Carboniferous which seem to explain this. They show a central hole or burrow from which the animal seems to have stretched and withdrawn its body in different directions, so as to give an appearance of branching and radiation, possibly due merely to the excursions of the same worm from the mouth of its burrow.

No distinct examples of the Primordial and Silurian worm-trails known as *Nereites*, *Myrianites* and *Crossopodia*, have yet occurred to me in the Carboniferous.

Diplichnites Dawson.

In the Journal of the Geological Society for 1861, I described a remarkable series of impressions found at the Joggins in the Coal-formation, on the surface of a sandstone holding footprints of reptiles. It consists of two rows of strongly marked depressions about one inch long and a quarter of an inch broad (fig. 3). These marks are placed close together in each row, and the rows are six inches apart, while the space between is somewhat smoothed as if by a flat body drawn over it. The general appearance is somewhat that which would be produced by a heavy-laden toy cart six inches wide, and with broad wheels, notched or cogged at the edges, if dragged over firm sand. I suggested, in the paper above mentioned, that these singular markings might have been produced by a large crustacean or by a gigantic worm, or by a serpentiform batrachian. I have since found a very perfect but smaller series on a sandstone of the Upper Coal-formation near Toney river, which in the varying distances of the impressions seems to show that they were made by prominent movable points, while the absence of any mark or smoothing between the rows shows that the body of the animal was borne above the sand. I have hence been induced to suppose that these imprints may have been produced by the pectoral or ventral fins of fishes armed with strong spines, on which the creatures may have executed a sort of walking movement when in shallow water. In my collection from the Joggins there is a spine which I have figured and described in my Acadian Geology under the name *Gyracanthus duplicatus*, which if we can suppose it to have been a pectoral or ventral spine, would produce precisely such impressions as those of the smaller series above mentioned. The

impressions of the type of Diplichnites are known to me only in the Carboniferous. Særichnites of Billings, from the Anticosti group,* has some points of resemblance to it, but is essentially distinct. My species may be named *D. ænigma.*

Rabdichnites Dawson.

Under this name I would designate the straight or slightly curved marks usually striated or grooved longitudinally, and either single or in pairs, which abound on some Carboniferous beds, and also in much older formations. At Horton Bluff, in beds holding remains of fishes and numerous footprints of crustaceans and reptiles, and scratches which were probably made by the fins of fishes, these marks abound. They were evidently furrows drawn by pointed objects trailed over the mud, and reproduced in relief on the under surfaces of the beds next deposited. Some have been produced by rounded points and are semi-cylindrical. Others are the work of chisel-shaped, pointed, notched or fimbriated organs, giving a variety of more or less close subordinate grooves or striæ. In some cases they pass into or are associated with punctures or impressions made perpendicularly like those last noticed, and this is especially the case with some of the smaller varieties. The whole of these impressions are probably marks of the spines and fins of fishes, striking the bottom or trailed over it. Some of the beds at Horton Bluff are as completely striated in this way as if glaciated, only that the striæ are individually more definite and are in all directions.

It is worthy of note that these markings strikingly resemble the so-called *Eophyton* described by Torell from the Primordial of Sweden, and by Billings from that of Newfoundland; and which also occurs abundantly in the Primordial of New Brunswick. After examining a series of these markings from Sweden shown to me by Mr. Carruthers in London, and also specimens from Newfoundland and a large number *in situ* at St. John, I am convinced that they cannot be plants, but must be markings of the nature of Rabdichnites. This conclusion is based on the absence of Carbonaceous matter, the intimate union of the markings with the surface of the stone, their indefinite forms, their want of nodes or appendages, and their markings being always of such a nature as could be produced by scratches of a sharp instrument. Since, however, fishes are yet unknown in beds of this age, they may possibly be referred to the feet or spinous tails of swimming crustaceans. Salter has already suggested this origin for some scratches of somewhat different form found in the Primordial of Great Britain. He

* Report on Silurian Fossils of Anticosti, 1866.

supposed them to have been the work of species of *Hymenocaris*. These marks may, however, indicate the existence of some free-swimming animals of the Primordial seas as yet unknown to us.

Three other suggestions merit consideration in this connection. One is that algæ and also land plants, drifting with tides or currents, often make the most remarkable and fantastic trails. A marking of this kind was observed by Mr. G. M. Dawson last summer to be produced by a Laminaria, and in complexity it resembled the extraordinary *Ænigmichnus multiformis* of Hitchcock from the Connecticut sandstones. Much more simple markings of this kind would suffice to give species of *Eophyton*. Another is furnished by a fact stated to the author by Prof. Morse, namely, that Lingulæ, when dislodged from their burrows, trail themselves over the bottom like worms, by means of their cirri. Colonies of these creatures, so abundant in the Primordial, may, when obliged to remove, have covered the surfaces of beds of mud with vermicular markings. The third is that the Rabdichnite-markings resemble some of the grooves in Silurian rocks which have been referred to trails of Gasteropods, as for instance, those from the Clinton group, described by Hall.

As might be expected, the markings above referred to, when in relief, occur on the under sides of the beds. A few instances may, however, be found where they exist on the upper surfaces. On careful consideration of these raised impressions, I have arrived at the conclusion that they have been left by denudation of the surrounding material, just as footprints on dry snow sometimes remain in relief after the surrounding loose snow has been drifted away by the wind; the portion consolidated by pressure being better able to resist the denuding agency. Such markings in relief on the upper surfaces of beds are, however, I believe, altogether exceptional.

It seems idle to give specific names to markings of this kind. They have evidently been made by many different species of animals, but they afford no certain characters. Fig. 4 *a* to *f*, represents some of the forms most common in the Carboniferous beds.

Imitative Markings.

Rill-marks are often very beautifully developed on the Carboniferous shales and argillaceous sandstones, though not more elaborately than on the modern mud-banks of the Bay of Fundy,* and they occur as far back as the oldest Cambrian.† Some of these simulate leaves of ferns and fronds of Laminariæ,

* Acadian Geology, 2nd ed., p. 26.

† Salter, Journal of Geol. Society, vol. xii, p. 251.

and others resemble roots, fucoids allied to Buthotrephis, or the radiating worm-burrows already referred to.

Shrinkage cracks are also abundant in some of the Carboniferous beds and are sometimes accompanied with impressions of rain-drops. When finely reticulated they might be mistaken for the venation of leaves, and when complicated with little rill-marks tributary to their sides, they precisely resemble the Dictuolites of Hall from the Medina Sandstone.

An entirely different kind of shrinkage-crack is that which occurs in certain carbonized and flattened plants, and which sometimes communicates to them a marvelous resemblance to the netted under-surface of an exogenous leaf (fig. 5). Flattened stems of plants and layers of cortical matter, when carbonized, shrink in such a manner as to produce minute reticulated cracks. These become filled with mineral matter before the coaly substance has been completely consolidated. A further compression occurs, causing the coaly substance to collapse, leaving the little veins of harder mineral matter projecting. These impress their form upon the clay or shale above and below, and thus when the mass is broken open we have a carbonaceous film or thin layer covered with a network of raised lines, and corresponding minute depressed lines on the shale in contact with it. The reticulations are generally irregular, but sometimes they very closely resemble the veins of a reticulately veined leaf. One of the most curious specimens in my possession was collected by Mr. Elder in the Lower Carboniferous of Horton Bluff. The little veins which form the projecting network are in this case white calcite; but at the surface their projecting edges are blackened with a carbonaceous film.

Slicken-sided bodies, resembling the fossil fruits described by Geinitz as *Gulielmites*, and the objects believed by Fleming and Carruthers* to be casts of cavities filled with fluid, abound in the shales of the Carboniferous and Devonian. They are, no doubt, in most cases the results of the pressure and consolidation of the clay around small solid bodies, whether organic, fragmentary or concretionary. They are, in short, local slickensides precisely similar to those found so plentifully in the coal under-clays, and which, as I have elsewhere† shown, resulted from the internal giving way and slipping of the mass as the roots of Stigmaria decayed within it. Most collectors of fossil plants in the older formations must, I persume, be familiar with appearances of this kind in connection with small stems, petioles, fragments of wood, and carpolites. I have in my collection petioles of ferns and fruits of the genus *Trigonocarpum* partially

* Journal of Geol. Society, June, 1871. † Ibid, vol. x, p. 14.

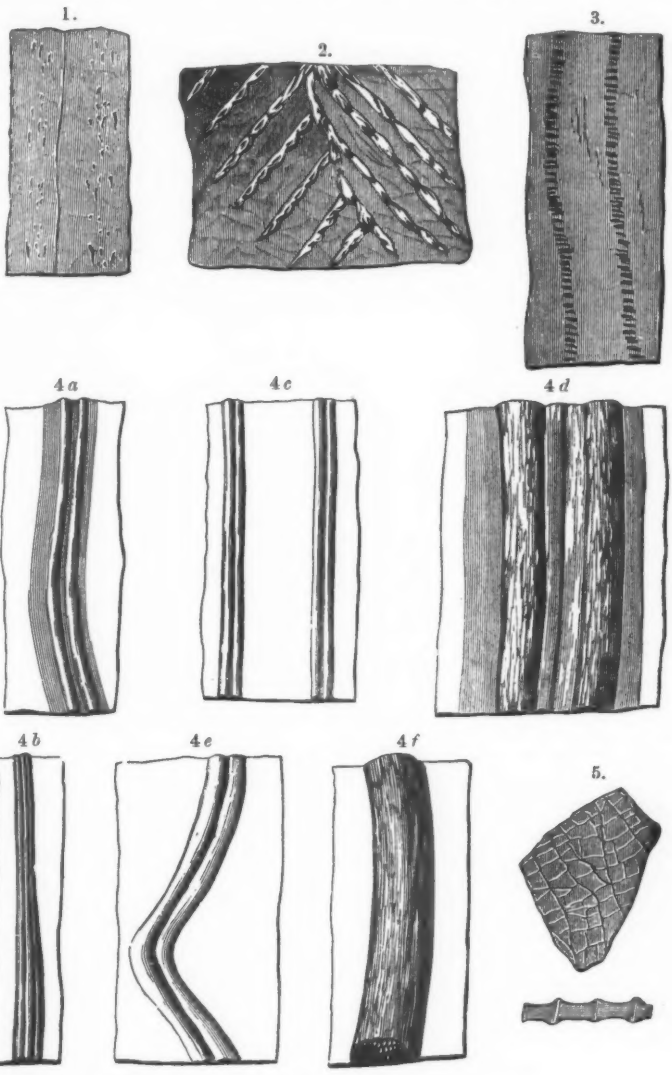


Fig. 1.—*Protichnites Carbonarius* (nat. size). Carboniferous, Nova Scotia.
Fig. 2.—*P. Acadicus*, " "
Fig. 3.—*Diplichnites ænigma* (reduced). " "
Fig. 4.—*Rabdichnites*, different forms (nat. size). " "
Fig. 5.—Carbonized plant with reticulated markings (nat. size); *a*, enlarged section of part of the same. Carboniferous, Nova Scotia.

slicken-sided in this way, and which if wholly covered by this kind of marking could scarcely have been recognized. I have figured bodies of this kind in figs. 126 and 231 of my report on the Devonian and Upper Silurian plants, believing them, owing to their carbonaceous covering, to be probably slicken-sided fruits, though of uncertain nature. In every case I think these bodies must have had a solid nucleus of some sort, as the severe pressure implied in slicken-siding is quite incompatible with a mere "fluid-cavity," even supposing this to have existed.

Prof. Marsh has well explained another phase of the influence of hard bodies in producing partial slicken-sides, in his paper on *Stylolites*, read before the American Association in 1867, and the application of the combined forces of concretionary action and slicken-siding to the production of the cone-in-cone concretions, which occur in the Coal-formation and as low as the Primordial, was illustrated by the author in his Acadian Geology, p. 676.

Of course, as I have not seen the specimens referred by Prof. Geinitz to Gulielmites, but only the figures in his Memoir on the Permian plants of Saxony, I cannot offer any decided opinion as to their nature; but I have little doubt that the bodies mentioned by Mr. Carruthers are of the kind above referred to, and would be found to have had a solid nucleus either organic or of some other kind.

I may remark in conclusion that it would be well if collectors would give some attention to imitative markings and animal footprints of the kinds above referred to, as well as to their mode of occurrence with reference to the surfaces and material of the beds on which they are found. The labors of Hitchcock and others show how much interesting information may thus be obtained, and many mischievous errors might also be avoided. In my own studies in fossil botany, I have made it a point to collect and study all markings resembling plants, as well as the effects of crumpling, pressure, concretionary action, crystalization, shrinkage and slicken-siding upon actual vegetable remains; and by so doing I have avoided the trouble and expense of describing and figuring some dozens of imaginary species; while it would be easy to point out in works of some pretension costly figures and elaborate descriptions based on imitative forms or distorted and otherwise altered fossils.

ART. III.—*Researches in Actino-chemistry.* MEMOIR SECOND. *On the Distribution of Chemical Force in the Spectrum;* by JOHN WILLIAM DRAPER, M.D., LLD., President of the Faculties of Science and Medicine in the University of New York.

WITH scarcely an exception, the most recent works on the chemical action of radiations and spectrum analysis describe a tripartite arrangement of the spectrum, illustrated by an engraving of three curves, exhibiting the supposed relations of the calorific, the luminous, and the chemical spectra. This view, which by a mass of evidence may be shown to be erroneous, is exerting a very prejudicial effect on the progress of actino-chemistry.

I propose now to present certain facts which may aid in correcting this error. For this purpose it is necessary to show that chemical effects—decompositions and combinations—may take place in any part of the spectrum. The points to be established may be thus distinctly stated:

1st. That so far from chemical influences being restricted to the more refrangible rays, every part of the spectrum, visible and invisible, can give rise to chemical changes, or modify the molecular arrangement of bodies.

2d. That the ray effective in producing chemical or molecular changes in any special substance is determined by the absorptive property of that substance.

I may here remark that both these propositions were maintained by me many years ago; an example of the first will be found in the Philosophical Magazine (Dec., 1842), and of the second in a paper in the same journal, "On some analogies between the phenomena of the chemical rays and those of radiant heat" (Sept., 1841).

The opinion commonly held respecting the distribution of chemical force in the spectrum, is mainly founded on the behavior of some of the compounds of silver. These darken when exposed to the more refrangible rays, and unless correct methods of examination be resorted to, seem to be unaffected by the less refrangible. Hence it has been supposed, that in the higher parts of the spectrum a special principle prevails, to which the designation of "actinic rays" is often applied—an inappropriate iteration. In these pages I use the derivatives of ἀκτίς, not in this restricted sense, but as expressive of radiations of every kind. This is their proper signification.

Every part of the spectrum, no matter what its refrangibility may be, can produce chemical changes, and therefore there is no special localization of force in any limited region. Out of a large body of evidence that might be adduced, I select a few prominent instances.

1st—Case of the Compounds of Silver.

Silver is the basis of the most important photographic sensitive substances. Its iodide, bromide and chloride, darkening with rapidity under the influence of the more refrangible rays, have mainly been the cause of the misconception above alluded to respecting the tripartite constitution of the spectrum. It is necessary, therefore, to determine what are really the habitudes of these substances.

(1.) If a spectrum be received on iodide of silver, formed on the metallic tablet of the daguerreotype, and carefully screened from all access of extraneous light, both before and during the exposure, on developing with mercury vapor an impression is evolved in all the more refrangible regions. This stain corresponds in character and position to the blackening effect which under like circumstances would be found on any common sensitive silver paper. It is this which has given rise to the opinion that the so-called actinic rays exist only in the upper part of the spectrum. If, however, the action of the light be long continued, a white stain makes its appearance over all the less refrangible regions. It has a point of maximum to which I shall again presently refer.

(2.) But if the metallic tablet during its exposure to the spectrum be also receiving diffused light of little intensity, as the light of day or of a lamp, it will be found on developing that the impression obtained differs strikingly from the preceding. Every ray that the prism can transmit, from below the extreme red to beyond the extreme violet, has been active. The ultra-red heat lines α, β, γ, are present. It must be borne in mind that the impression of these lines is a proof of proper spectrum action, and distinguishes it from that of diffused light, arising either from the atmosphere or from the imperfect transparency of the prism—a valuable indication. The resulting photograph shows two well marked regions or phases of action. On its general surface, which, having condensed the mercury vapor, has the aspect of the high lights of the daguerreotype, and forms as it were the basis for the spectrum picture, there is in the region of the more refrangible rays a bluish or olive-colored impression, the counterpart of the result described in the foregoing paragraph. But in the region of the less refrangible rays no mercurial deposit has occurred, the place of those rays being depicted in metallic silver, dark, and answering to the shadows of the daguerreotype. This protected portion, which stands out in bold relief from the white background, reaches from a little below G to beyond the extreme red, and encloses the heat lines above named. They are in the form of white streaks. Though I speak of them as single lines, they are in reality groups or perhaps bands.

The general appearance of the photograph at once suggests that the less refrangible rays can arrest the action of the daylight, and protect the silver iodide from change. A close examination shows that there are three points, the extreme red, the center of the yellow, and the extreme violet, which apparently can hold the daylight in check. There are also two intervening ones in which the actions conspire. The point of maximum protection corresponds to the point of maximum action referred to above in paragraph (1).

(3.) If the metallic tablet, previously to its exposure to the spectrum, be submitted for a few moments to a weak light, so that were it developed it would at this stage whiten all over, the action of the spectrum upon it will be the same as in the last case (2). But this change in the mode of the experiment leads to a very important conclusion. The less refrangible rays can reverse or undo the change, in whatever it may consist, that light has *already* impressed on the iodide of silver.

Now bearing in mind the facts, that the photographic action of diffused light on this iodide is mainly due to the more refrangible rays it contains, we are brought by these experiments to the following conclusions:

1st. Every ray in the spectrum acts on silver iodide.

2d. The more refrangible rays apparently promote the action of the daylight on that substance; the less refrangible apparently arrest it.

3d. For the display of this arresting or antagonizing effect, it is not necessary that the less and more refrangible rays should be acting *simultaneously*. An interval may elapse and they may act *successively*. Hence the effect is not due to the contemporaneous interference of waves of different periods of vibration with one another—the material particles of the changing substance of the silver iodide are involved.

I abstain for the moment from giving further details of these spectrum impressions. That has been very completely done by Herschel, in the case of one I sent him many years ago. His examination of it, illustrated by a lithograph, may be found in the Philosophical Magazine (Feb., 1843). I shall have to return to the subject of the behavior of silver iodide in presence of radiations on a subsequent page of this memoir.

The main point at present established is this, that the silver iodide under proper treatment is affected by every ray that a flint glass prism can transmit, and therefore it is altogether erroneous to suppose that chemical force is restricted to the more refrangible portions of the spectrum.

2d.—*Case of Bitumens and Resins.*

These substances are of special interest in the history of photography, since in the hands of Niépcè they probably were the

first on which impressions in the camera were obtained and fixed. Their use has been abandoned in consequence as it seems to me of an incorrect opinion of their want of sensitiveness. Properly used, they are scarcely inferior to chloride of silver.

The theory of their use is very simple. Alcohol, ether, and various volatile oils, respectively dissolve certain portions of these substances. If such a solution be spread in a thin film upon glass, as in the collodion operation, and parts of the surface be then exposed to light, the portions so exposed become insoluble in the same menstruum. They may therefore be developed by its use. Practically, care has to be taken to moderate the solvent action, and to check it at the proper time. The former is accomplished by dilution with some other appropriate liquid, the latter by the affusion of a stream of water.

The substance I have used is West India bitumen dissolved in benzine, and developed by a mixture of benzine and alcohol.

The bitumen solution being poured on a glass plate in a dark room, and drained off as in the operation of collodion, leaves a film sufficiently thin to be iridescent. This is exposed to the spectrum for five minutes, and then developed.

The beginning of the impression is below the line A, its termination beyond H. Every ray in the spectrum acts. The proof is continuous except where the Fraunhofer lines fall. A better illustration that the chemical action of the spectrum is not restricted to the higher rays, but is possessed by all, could hardly be adduced.

3d.—Case of Carbonic Acid.

The decomposition of carbonic acid by plants under the influence of sunshine, is undoubtedly the most important of all actino-chemical facts. The existence of the vegetable world, and indeed it may be said the existence of all living beings, depends upon it.

I first effected this decomposition in the solar spectrum, as may be found in a memoir in the Philosophical Magazine (Sept., 1843). The results obtained by me at that time from the direct spectrum experiment, that the decomposition of carbonic acid is effected by the less, not by the more refrangible rays, have been confirmed by all recent experimenters, who differ only as regards the exact position of the maximum. In the discussions that have arisen this decomposition has often incorrectly been referred to the *green* parts of plants. Plants which have been caused to germinate and grow to a certain stage in darkness are etiolated. Yet these, when brought into the sunlight, decompose carbonic acid, and *then* turn green. The chlorophyl thus produced is the effect of the decomposition, not its cause. Facts derived from the visible absorptive action of chlorophyl do not necessarily apply to the decomposition of

carbonic acid. The curve of the production of chlorophyl, the curve of the destruction of chlorophyl, the curve of the visible absorption of chlorophyl, and the curve of the decomposition of carbonic acid, are not all necessarily coincident. To confound them together, as is too frequently done, is to be led to incorrect conclusions.

Two different methods may be resorted to for determining the rays which accomplish the decomposition of carbonic acid.

1st, The place of maximum evolution of oxygen gas in the spectrum may be determined. 2d, the place in which young etiolated plants turn green.

I resorted to both these methods, and obtained from them the same results. The rays which decompose carbonic acid are the same which turn etiolated plants green. They may be designated as the yellow with the orange on one side, and a portion of green on the other. Though the form of experimentation does not admit a close reference to the fixed lines, I think we are almost justified in supposing that the point of maximum action is in the yellow. It must be borne in mind, that the rapidly increasing concentration of the rays occasioned by the peculiarity of prismatic dispersion toward the red end, will give a deceptive preponderance in that direction. Without entering further into this discussion, it is sufficient for my present purpose to understand that the decomposition in question is accomplished by rays between the fixed lines B and F.

The two absorptive media, potassium bichromate, and cupro-ammonium sulphate, so often and so usefully employed in actino-chemical researches, corroborate this conclusion. Plants cannot decompose carbonic acid, nor can they turn green in rays that have passed through a solution of the latter salt. They accomplish both those results in rays that have passed through the former.

The decomposition of carbonic acid, and the production of chlorophyl by the less refrangible rays of the spectrum, afford thus a striking illustration that chemical changes may be brought about by other than the so-called chemical rays.

4th.—Case of the Colors of Flowers.

The production and destruction of vegetable colors by the agency of light has of course long been a matter of common observation. Little has, however, been done in the special examination of the facts, and that little for the most part by Herschel.

We have only to examine his memoir in the Philosophical Transactions (part II, 1842), to be satisfied that nearly every radiation can produce effects. Thus the yellow stain imparted by the *Corchorus Japonica* to paper is whitened by the green, blue, indigo and violet rays. The rose-red of the *Ten weeks*

stock is in like manner changed by the yellow, orange and red. The rich blue tint of the *Viola odorata*, turned green by sodium carbonate, is bleached by the same group of rays, that is, by those less refrangible than the yellow. The green (chlorophyl) of the *Elder* leaf is changed by the extreme red.

It is needless to extend this list of examples. The foregoing establish the principle, that every part of the spectrum displays activity, some vegetable colors being affected by one, others by other rays. It is, however, desirable that the general principle at which Herschel arrived, viz: that the *luminous* rays are chiefly effective, should be more closely examined. Some important physiological explanations turn on that principle. These so-called luminous rays are such as can impress the retina, which like organic colors is a carbon compound. There are strong reasons for inferring that carbon is affected mainly by rays, the wave-lengths of which are between those of the extreme red and extreme violet, the maximum being in the yellow.

It is, however, to a former experimenter, Grotthus, that we owe the discovery of the law under which these decompositions of the colors of flowers take place. This law in repeated instances was verified by Herschel, and more recently by myself. It may be thus expressed. "The rays which are effective in the destruction of any given vegetable color are those which by their union produce a tint complementary to the color destroyed." Even the partial establishment of this law, already accomplished, is sufficient to prove that chemical effects are not limited to the more refrangible portions of the spectrum, but can be occasioned by any ray.

5th.—Case of the union of Chlorine and Hydrogen.

In the Philosophical Magazine (December, 1843) may be found the description of an actinometer invented by me, depending for its indications on the combination of chlorine and hydrogen, these gases having been evolved in equal volumes from hydrochloric acid by a small voltaic battery. This instrument, modified to suit their purposes, was used by Professors Bunsen and Roscoe in their photometrical researches. Many of my experiments were repeated by them (Transactions of the Royal Society, 1856, 1857).

In Table III. of my memoir, above referred to, it is shown that this mixture is affected by every ray of the spectrum; but by different ones with very different energy. The maximum is in the indigo, the action there being more than 700 times as powerful as in the extreme red.

6th.—Case of the Bending of the Stems of Plants in the Spectrum.

It is a matter of common observation, that plants tend to grow toward the light. Dr. Gardner was, however, the first to

examine the details of this phenomenon in the spectrum. His memoir is in the Philosophical Magazine (Jan., 1844). When seeds are made to germinate and grow for a few days in darkness, they develop vertical stems, very slender and some inches in length. These, on being placed so as to receive the spectrum, soon exhibit a bending motion. The stems in other parts of the spectrum turn toward the indigo; those in the indigo bend to the approaching ray. Removed into darkness, they recover their upright position. These movements are the most striking of all actinic phenomena. I have often witnessed them with admiration.

Dr. Gardner's experiments were repeated and confirmed by M. Dutrochet, who, in a report to the French Academy of Sciences (Comptes Rendus No. 26, June, 1844), added a number of facts respecting the bending of roots *from* the light, which he found to be occasioned by all the colored rays of the spectrum.

In Dr. Gardner's paper there are also some interesting facts respecting the bleaching or decolorization of chlorophyl by light. He used an ethereal solution of that substance:—

"The first action of light is perceived in the mean red rays, and it attains a maximum incomparably greater at that point than elsewhere. The next part affected is in the indigo, and accompanying it there is an action from + 10·5 to + 36·0 of the same scale (Herschel's) beginning abruptly in Fraunhofer's blue. So striking is this whole result, that some of my earlier spectra contained a perfectly neutral space, from −5·0 to +20.5, in which the chlorophyl was in no way changed, whilst the solar picture in the red was sharp and of a dazzling white. The maximum in the indigo was also bleached, producing a linear spectrum, as follows:

In which the orange, yellow and green rays are neutral. These it will be remembered are active in forming chlorophyl. Upon longer exposure the subordinate action along the yellow, etc., occurs, but not until the other portions are perfectly bleached.

"In Sir J. Herschel's experiments there remained a salmon color after the discharge of the green. This is not seen when chlorophyl is used, and is due to a coloring matter in the leaf, soluble in water, but insoluble in ether."

I have quoted these results in detail because they illustrate in a striking manner the law that *vegetable colors are destroyed by rays complementary to those that have produced them*, and furnish proof that rays of every refrangibility may be chemically active.

At this point I abstain from adding other instances showing that chemical changes are brought about in every part of the spectrum. The list of cases here presented might be indef-

initely extended, if these did not suffice. But how is it possible to restrict the chemical force of the spectrum to the region of the more refrangible rays, in face of the facts that compounds of silver such as the iodide, which have heretofore been mainly relied upon to support that view and, in fact, originated it, are now proved to be affected by every ray from the invisible ultra-red to the invisible ultra-violet; how when it is proved that the decomposition of carbonic acid, by far the most general and most important of the chemical actions of light, is brought about not by the more refrangible, but by the yellow rays? The delicate colors of flowers, which vary indefinitely in their tints, originate under the influence of rays of many different refrangibilities, and are bleached or destroyed by spectrum colors complementary to their own, and. therefore, varying indefinitely in their refrangibility. Toward the indigo ray the stems of plants incline; from the red their roots turn away. There is not a wave of light that does not leave its impress on bitumens and resins, some undulations promoting their oxidation, some their deoxidation. These actions are not limited to decompositions; they extend to combinations. Every ray in the spectrum brings on the union of chlorine and hydrogen.

The conclusion to which these facts point is, then, that it is erroneous to restrict the chemical force of the spectrum to the more refrangible, or, indeed, to any special region. There is not a ray, visible or invisible, that cannot produce a special chemical effect. The diagram so generally used to illustrate the calorific, luminous, and chemical parts of the spectrum, serves only to mislead.

While thus we find that chemical action may take place throughout the entire length of the spectrum, the remarks that have been made in the previous memoir (this Journal, Sept., 1872), respecting the differences of calorific distribution in dispersion and diffraction, apply likewise to the chemical force. To be satisfied of this, it is only necessary to compare photographic impressions given by a prism and a grating!

I published engravings of such diffraction photographs in 1844. They are referred to in the Philosophical Magazine (June, 1845). As they were obtained on silver plates made sensitive by iodine, bromine and chlorine, they do not extend to the line F.

I had found that certain practical advantages arise from the use of a reflected instead of a transmitted spectrum. The ruled glass was, therefore, silvered upon its ruled face with tin amalgam, copying the surface perfectly. Of the series of spectra I used the first.

The fixed lines were beautifully represented in the photographs. They were, however, so numerous and so delicate,

that I did not attempt to do more than to mark the prominent ones. These were, I believe, the first diffraction photographs that had ever been obtained. The wave-lengths assigned were according to Fraunhofer's scale, which represents parts of a Paris inch.

The length of the photographic impression given by the prism I was then using, from the line H to the ultra-violet end of the spectrum, was about three times that from H to G; but in the spectrum by the grating, though the exposure was in one instance continued for a whole hour, the impression beyond H was not more than 1½ times the length of that to G. In more moderate exposures the last fixed line in the photograph was about as far from H on one side as G was on the other. This, therefore, showed very clearly the difference of distribution in the diffraction and prismatic spectra.

Of the Chemical Action of Radiations on Substances.

Having offered the foregoing evidence in support of the first proposition considered in this memoir, which was to the effect—

"That so far from chemical influences being restricted to the more refrangible rays, every part of the spectrum, visible and invisible, can give rise to chemical changes, or modify the molecular arrangement of bodies," I now pass to the second, which is—

"That the ray effective in producing chemical or molecular changes in any special substance, is determined by the absorptive property of that substance."

This involves the conception of selective absorption, as I have formerly shown (Phil. Mag., Sept., 1841). A ray which produces a maximum effect on one substance may have no effect on another. Thus the rays which change chlorophyl are not those which change silver iodide.

In the examination of this subject I shall select two well known instances, presenting the fewest elements and the simplest conditions. They are, 1st, the decomposition of silver iodide, the basis of so many photographic preparations. 2d, the production of hydrochloric acid by the union of its two constituents, chlorine and hydrogen—a mixture of these gases being exceedingly sensitive to light.

1st.—*Of the decomposition of silver iodide.*

There are two forms in which the silver iodide has been used for photographic purposes: 1st, when prepared by the action of the vapor of iodine on metallic silver, as in the daguerreotype tablet; 2d, when nitrate of silver is decomposed by iodide of potassium, or other metallic iodides. These preparations differ strikingly in their actinic behavior, the former furnishing by far the most interesting series of facts.

When a polished surface of silver is exposed at common temperatures to the vapor of iodine, it speedily tarnishes, a film of silver iodide forming. This passes through several well marked tints, as the exposure continues and the thickness increases. They may be thus enumerated in the order of their occurrence: 1, lemon-yellow; 2, golden-yellow; 3, red; 4, blue; 5, lavender; 6, metallic; 7, deep yellow; 8, red; 9, green.

All these films are sensitive. Under the influence of radiations they exhibit two phases of modification. 1st, an invisible modification, which, however, can be made apparent or developed, as Daguerre discovered, by exposure to the vapor of mercury, the iodide turning white by the condensation of mercury upon it, wherever it has been exposed to light; but remaining unacted upon in parts that have been in shadow. 2d, a visible modification, which arises under a longer exposure, the iodide passing through various shades of olive and blue, and eventually becoming dark-gray.

But though all the variously tinted films of silver iodide are impressionable, they differ greatly in relative sensitiveness, when compared with each other. This may be very satisfactorily shown by producing on one silver tablet bands of all the above named colors, an effect readily accomplished by suitably unscreening successive portions of the tablet during the process of iodizing, and then exposing all at the same time to a common radiation. It will be found on developing with mercury vapor that the bands of a yellow color have been the most sensitive, those of a metallic aspect have been scarcely acted on, and those of other tints intermediately. It is to be particularly remarked that the second yellow, numbered 7 in the above series, is equally sensitive with the first yellow, numbered 2.

From this it appears that the sensitiveness of this form of iodide depends not merely on its chemical constitution, but also on its optical properties. The explanation of this different sensitiveness in different films of iodide becomes obvious when we cause a tablet prepared as just described with tinted bands to reflect the radiations falling on it to another tablet iodized to a yellow color, and placed in a camera. After due exposure and development of both with mercury, it will be found that the image of the first tablet formed on the second consists of bands of different shades of whiteness. The yellow parts of the first tablet have scarcely affected the second, but its metallic and blue parts have acted very powerfully. On comparing the first plate and its image on the second together, it will be perceived that the parts that have been affected on the one are less affected on the other.

It may therefore be inferred that the yellow films are sensitive because they absorb the incident radiation, and the metallic and blue are insensitive because they reflect it.

The effect, in whatever it may consist, which occurs during the invisible modification, is not durable: it gradually passes away. If tablets that have received impressions be kept for a time before developing, the images upon them gradually disappear. On these tablets there is no lateral propagation of effect, nothing answering to conduction.

On examining the operation of a radiation continuously applied to one of these sensitive films, it will be discovered that a certain time elapses—that is, a certain amount of the radiation is consumed—before there is any perceptible effect. When that is accomplished the radiation affects the film to a degree proportional to its quantity, until a second stage is reached; there is then another pause followed by the second stage, in which visible modification or chemical decomposition sets in. The film begins to darken; it passes through successive tints, brown, red, olive, blue, and eventually becomes dark grey.

I have described in some of the foregoing paragraphs the action of the spectrum on silver iodide, as presented on the tablet of the daguerreotype, showing the difference in the impression obtained: 1st, when extraneous light has been excluded; and 2d, when it has been permitted simultaneously or previously to act.

In the latter case, in all that region of the spectrum from the more refrangible extremity to somewhat below the line G, the usual darkening effect manifested by silver compounds is observed, but beyond this, and to the extreme less refrangible rays, with certain variations of intensity, the action of the extraneous and simultaneously acting light is checked, and the effect of previously acting light is destroyed.

It happened that in 1842 I obtained two very fine specimens of the latter spectra; one of these I sent to Sir J. Herschel, the other is still in my possession.

In the Philosophical Magazine (Feb., 1843), Herschel gave a detailed description of these spectrum impressions. He was disposed to refer the appearance they present to the phenomena of thin films, but at the same time pointed out the difficulties in the way of that explanation. He also sent me three proofs he had obtained on ordinary sensitive paper, darkened by exposure to light, then washed with a solution of iodide of potassium, and placed in the spectrum. He described them as follows:

(1.) "Blackened paper from which excess of nitrate of silver has not been abstracted, under the influence of an iodic salt. Produced by a November sun. N. B.—View it also transparently against the light."

(2.) "Blackened paper under the influence of an iodic salt, when no excess of nitrate of silver exists in the paper."

(3.) "Action of spectrum under iodic influence when very little nitrate of silver remains in excess in the paper. To be viewed also transparently."

These paper photographs I still preserve. They are as perfect as when first made. The different colored spaces of the spectrum are marked upon them with pencil. The appearances they respectively present are as follows: (1) is bleached by the more refrangible rays, and blackened deeply from the yellow to the ultra-red; (2) is bleached from the ultra invisible red to the ultra-violet: a maximum occurs abruptly about the blue; (3) has the same upper spectrum as the others, a bleached dot in the center of the yellow, and a darkened space on the extreme red. The action has reached from the ultra-red to the ultra-violet.

In Herschel's opinion, these effects in the less refrangible region are connected with the drying of the paper. It is well known that paper in a damp condition is more sensitive than such as is dry. But obviously this condition does not obtain in the case of the daguerreotype operation, which is essentially a dry process.

In 1846 MM. Foucault and Fizeau, having repeated the experiment originally made by me, presented a communication to the French Academy of Sciences to the effect that when a silver tablet which has been sensitized by exposure to iodine and bromine, and then impressed by light, is exposed to the spectrum, the effect is greatly increased in all the region above the line C, and is neutralized in all that below C. They remarked the distinctness with which the atmospheric line A comes out, and saw the ultra spectrum heat-rays α, β, γ, described by me some years previously.

The interpretation given by them is, that the more refrangible rays promote the previous action of light; the less neutralize it. The curve representing the chemical intensity of the different rays would cross the axis of abscissas about the boundary of the red and orange; below that point to the ultra-red the ordinates would have negative values; above it to the ultra-violet those values would be positive (Comptes Rendus, No. 14. tome 23).

Hereupon M. Becquerel communicated to the same Academy a criticism on this interpretation, the opinion maintained by him being that while the more refrangible rays excite sensitive surfaces, the less refrangible, far from neutralizing, continue the action so begun. To the former he gave the designation "rayons excitateurs," to the latter "rayons continuateurs" (Comptes Rendus, No. 17, tome 23).

In 1847 M. Claudet communicated a paper to the Royal Society, subsequently published in the Philosophical Magazine (Feb., 1848), on this subject. His attention had been drawn to it by observing that the red image of the sun, during a dense fog, had destroyed the effect previously produced on a sensitive silver surface, and that this destruction could be occasioned at pleasure by the use of red and yellow screens. A surface which has been impressed by daylight, and the impression then obliterated by the less refrangible rays, had recovered its primitive condition. It was ready to be impressed again by daylight, and again the resulting effect might be destroyed. Claudet found that this excitation and neutralization might be repeated many times, the chemical constitution of the film remaining unchanged to the last.

These facts seem to be inconsistent with Herschel's opinion, that positive and negative pictures may succeed each other by the continued action of a radiation, on the principle of Newton's rings.

On a collodion surface such negative neutralizing or reversing actions cannot be obtained by the less refrangible rays. The spectrum impression developed in the usual manner by an iron salt presents a sudden maximum about the line G, and continues thence to the highest limit of the spectrum. In the other direction it extends below F. From E to the ultra-red not a trace of action can be detected. The lines α, β, γ, cannot be obtained on collodion. There is, therefore, a difference between its behavior under exposure to light and that of a daguerreotype tablet.

The reversals that are obtained on collodion by the use of certain haloid compounds, are altogether different from the reversals on the thin films of a silver tablet. They are produced by the *more* refrangible rays.

On exposing a collodion surface prepared in the usual manner to daylight, long enough to stain it completely, then washing off the free nitrate, and in succession dipping the plate into a weak solution of iodide of potassium, exposing it to the spectrum, washing, again dipping it in the nitrate bath, and finally developing, a reversed action is obtained. The daylight is perfectly neutralized, but not after the manner in a daguerreotype. In the region about G, the place of maximum action in collodion, the impression of the light is totally removed by an exposure of five seconds. In twelve seconds the protected space is much larger; in thirty seconds it has spread from F to H. It is, however, to be particularly remarked that the less refrangible rays show no action.

The results are substantially the same when, instead of iodide of potassium, the chloride of sodium, corrosive sublimate, bro-

mide of potassium, or fluoride of potassium, is used. In all these the reversing action is from F to H, and has its maximum somewhere about G. That is, the reversing action coincides with the direct action; there is no protection in the lower portion of the spectrum as in the daguerreotype. The effect is altogether due to the change of composition of the sensitive film. Ordinarily it contains free nitrate; now it contains free iodide, chloride, &c.

The silver compounds of collodion absorb the radiations falling on them which are capable of producing a photographic effect. Yet sensitive as it is, collodion is very far from having its maximum sensitiveness, as is shown by the following experiment, which is of no small interest to photographers. I took five dry collodion plates, prepared by what is known as the tannin process, and having made a pile of them, caused the rays of a gas flame to pass through them all at the same time. On developing it was found that the first plate was strongly impressed, and the second, which had been behind it, apparently quite as much. Even the fifth was considerably stained. From this it follows that the collodion film, as ordinarily used, absorbs only a fractional part of the rays that can affect it. Could it be made to absorb the whole, its sensitiveness would be correspondingly increased.

Radiations that have suffered complete absorption can bring about no further change. Partial absorption, arising from inadequate thickness, may leave a ray possessed of a portion of its power. There must be a correspondence between the intensity of the incident ray and the thickness of the absorbing medium to produce a maximum effect.

Though the silver iodide is affected by radiations of every refrangibility, it is decomposed so that a subiodide results only by those of which the wave-length is less than 5000. If in presence of metallic silver, as on the daguerreotype tablet, the iodine disengaged unites with the free silver beneath. The rays of high refrangibility occasion in it chemical decomposition, those of less refrangibility, physical modification. In the language of the older theories of actino-chemistry, this substance may be said to exert a selective absorption. In this it illustrates the general principle, that it depends on the nature of the ponderable material presented to radiations which of them shall be absorbed.

(To be continued.)

ART. IV.—*On the relation between Color and Geographical Distribution in Birds, as exhibited in Melanism and Hyperchromism;* by ROBERT RIDGWAY.

(Continued from vol. iv, page 460.)

RED is a color which is similarly, or even more strongly, modified; but in the two regions which we have mentioned it is affected in two different ways (see vol. iv, p. 454): these are (1) with *latitude*, its *intensity* increasing toward the equator; and (2) with *longitude*, its *extent* increasing toward the Pacific coast. Examples of the first case are to be found in the middle American forms of *Cardinalis Virginianus* var. *carneus** (western coast, from Colima to Realejo), and var. *coccineus*† (eastern coast, from Miradór to Honduras), in which the red is altogether deeper than in the northern forms (var. *Virginianus* and var. *igneus*).‡§ In the case of *Pyranga æstiva*, Central American specimens are quite appreciably deeper red than northern ones. In *Carpodacus frontalis*, the potency of the peculiar laws of both regions is very evident. Mexican examples (var. *hæmorrhous*)‖ are characterized by the greater intensity and more strict confinement within their normal limits of the red areas of the plumage. Pacific coast specimens (var. *rhodocolpus*)¶ show a greater or less tendency to have the red *spread*, as it were, beyond the bounds of its normal pattern. In extreme specimens from Lower California and the southern coast region of Upper California, the red even covers all the plumage, except

* CARDINALIS VIRGINIANUS var. CARNEUS.
Cardinalis carneus Less., Rev. Zool., 1842, 209 (Acapulco et Relego).—Bonap. Consp., 501. (Female.)
Cardinalis Lessoni Bonap., Consp., p. 209. (Young Male.)
Hab. West Coast of middle America, from Colima to Realejo.

† CARDINALIS VIRGINIANUS var. COCCINEUS.
Cardinalis Virginianus var. *coccineus* Ridgway.
Hab. Atlantic coast of middle America, from Xalapa to Honduras; Yucatan.

‡ CARDINALIS VIRGINIANUS var. IGNEUS.
Cardinalis igneus Baird, Pr. A. N. S., 1859, 305 (Cape St. Lucas).
Hab. Cape St. Lucas, Arizona, and western Mexico, south to the Tres. Marias Islands.

§ It is somewhat remarkable that in these southern races (including var. *igneus*, in which the feature is most exaggerated) the black before the eye is much restricted, and does not cross the forehead (except sometimes very narrowly) as in the northern var. *Virginianus*.

‖ CARPODACUS FRONTALIS var. HÆMORRHOUS.
Fringilla hæmorrhoa Wagl., Isis, 1831, 525.—*Carpodacus hæm.* Scl., P. Z. S., 1856, p. 304; 1858, 303; 1859, 380.—Cat. Am. B., 1862, 122.—Baird, B. N. Am., 1858, 417.
Hab. Table-lands and elevated regions of Mexico.

¶ CARPODACUS FRONTALIS var. RHODOCOLPUS.
Carpodacus rhodocolpus Caban., Mus. Hein., p. 166.—Scl., P. Z. S., 1856, 304; 1857, 127.
Hab. Pacific coast of southern California and Mexico (south to Colima), and Peninsula of Lower California.

the wings and tail; *but, in all cases, it is brightest within those limits to which it is confined in the normal pattern.* The specimens from the Middle Province of the U. S. (var. *frontalis*)* may be taken as representing the normal style, for it is from this central race that the two extreme differentiations diverge.

This tendency to an extension of red, as we approach to the Pacific coast, is strictly paralleled in the case of *Sphyropicus varius.* Taking specimens of this species from the Atlantic States (typical *S. varius*)†, it is noticed that in the male the red patch on the throat is entirely cut off from the white rictal stripe by a continuous maxillary stripe of black, while the nuchal band is brownish white; and that the female has the throat entirely white. Not more than one per cent. have a tinge of red on the nape in the male, or a trace of it on the throat in the female. In specimens from the Rocky Mountains (var. *nuchalis*)‡ we find that *all* have the nuchal band more or less red, while the female invariably has the throat at least one-third of this color; the male, too, has the black maxillary stripe interrupted, allowing the red of the gular patch to touch, for quite a distance, the white stripe beneath the eye, while it invades, for a greater or less extent, the black pectoral crescent. Another step is seen in specimens from the region between the Rocky Mountains and the Cascade Range, in which the red is extended still more; first, the black auricular stripe has a few touches of red, the black pectoral crescent is mixed with red feathers, and the light area surrounding it (sulphur yellow in the more eastern styles) is more or less tinged with red; then as we continue westward the red increases more and more, until in specimens from the coast region of California, Oregon, Washington Territory, and British Columbia (var. *ruber*)§ it overspreads the whole head, neck and breast, in extreme examples entirely obliterating the normal pattern, though, usually, this can be distinctly traced. With

* CARPODACUS FRONTALIS, var. FRONTALIS.
Fringilla frontalis Say, Long's Exp., ii, 40.—*Carpodacus frontalis* Bonap., Consp., 533.—Baird, B. N. Am., 1858, 415.
Carpodacus familiaris McCall, P. A. N. S., vii, p. 61.
Hab. Middle Province of the U. S., including the Sierra Nevada and Rocky Mts., and southern border from the Rio Grande to Fort Tejon, Cal.

† SPHYROPICUS VARIUS var. VARIUS.
Picus varius Linn., S. N., i, 176.—*Sphyropicus varius* Baird, B. N. Am., 1858, 103.—Scl., Cat., 1862, 335.
Hab. Eastern Province of North America (breeding north of 40°); Mexico (both coasts).

‡ SPHYROPICUS VARIUS var. NUCHALIS.
Sphyropicus varius var. *nuchalis* Baird, B. N. Am., 1858, 103 (sub. *S. varius*).
Hab. Rocky Mts. and middle Province of U. S.

§ SPHYROPICUS VARIUS var. RUBER.
Picus ruber Gm., S. N., i, 1788, 429.—*Sphyropicus ruber* Baird, B. N. Am., 1858, 104.
Hab. Pacific Province of U. S. (east only to western slope of Sierra Nevada and Cascade Ranges).

this increase in the extent of red, there is also a gradually increased amount of black, strictly parallel to that in *Picus villosus* (var. *Harrisii*) and *P. pubescens* (var. *Gairdneri*) from the same regions (see vol. iv, p. 456).

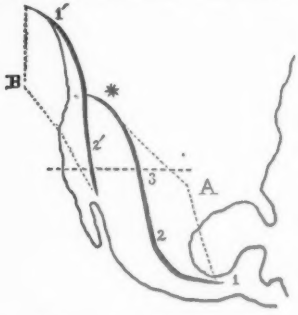
A case of increased intensity and prevalence of blue is clearly illustrated in the crested jays (*Cyanura*) of the western and interior mountain system of North America. Starting with *C. macrolopha*, the extreme northern form of the central mountains, we find the head and crest deep black, and the body dark ashy; proceeding southward, the blue gradually increases, first tinging the head and crest in specimens from the southern Rocky Mountains (in which the body becomes lighter and more bluish ashy); in specimens from the central table lands of Mexico (var. *diadematα*) the blue tinge is much more appreciable, while in those from the lower and hotter lands of Vera Cruz and Honduras (var. *coronata*) it entirely subdues the black, the bird being almost wholly blue.

All these forms we refer to *C. coronata* (the first described), the specific characters of which, as distinguished from the *C. Stelleri*, in its two races, of the Pacific coast, consist in the white supraocular spot, barred greater wing-coverts, and distinctly grayish white throat—characters shared alike by the three races named. It is possible, however, that even the *C. Stelleri* may yet also have to be combined with these, for specimens of *C. macrolopha* from the most northern Rocky Mountains of the U. S. incline so decidedly toward *C. Stelleri* that we either have to adopt this view, or consider them as hybrids between the two.

C. Stelleri exists in two very well marked, though of course intergrading, forms; the typical *stelleri* is confined to the northern coast region, from Sitka to the Columbia river, and is characterized by a short crest, entirely black head without any blue on the forehead, and by sooty black body, and uniform blue of wings, belly, rump, and tail. From the Columbia southward, along the Sierra Nevada to southern California, it is modified into a well marked form (var. *frontalis*), which has a longer crest, the head and crest grayish brown with conspicuous blue streaks on the forehead, brownish ashy body, and two different shades of blue—the indigo of the tail and secondaries being abruptly contrasted with the light azure of the rump, primaries, abdomen and tail-coverts. This form becomes more specialized, by the exaggeration of these characters, as it reaches its southern limit. In the conspicuously streaked forehead, lengthened crest, ashy body, and contrasted shades of blue, this form approximates closely to *C macrolopha* of a parallel latitude, *but does not grade into it*, there never being a white supraocular spot, barred greater coverts, or other peculiar features of the Rocky Mountain and Mexican form. That

the northern race of *C. Stelleri* should grade into *C. macrolopha*, and why the southern one does not, seems to be easily explained by the following facts: The habitat longitudinally of *C. coronata* (var. *macrolopha*) within the United States is exceedingly limited, it being confined to the central ranges of the Rocky Mountain system; thus it is everywhere separated from the habitat of *Stelleri* var. *frontalis*, which is equally restricted longitudinally by that broad desert expanse, the Great Basin, which affords no sheltering woods such as are furnished on the two boundary barriers, the Sierra Nevada and the Rocky Mountains, which each represents.

The northern limit to the range of *C. macrolopha* passes just a little beyond the southern limit of the habitat of the northern race of the coast stock, and at a latitude where the Great Basin becomes greatly reduced in width, or even terminates, and where the two great mountain systems become less distinctly separated. Consequently the coast stock cannot grade into the Rocky Mountain one, by approaching its habitat, until before it becomes modified into var. *frontalis*. Thus in the parallelism of modification between *Stelleri* var. *frontalis* and *coronata* var. *macrolopha*, as we trace the two forms southward, we recognize merely the effect of a latitudinal influence. The coast stock reaches its southern limit with the Sierra Nevada, and this of course prevents it from passing into *C. coronata* var. *diadematа*.



The proportionate relationship of these two forms may be more clearly illustrated by the following diagram and synopsis; the letters and figures of the former representing those of the latter:

A. Supraocular spot of white; greater wing-coverts barred with black; chin and throat abruptly lighter than adjacent parts (*C. coronata*).

1. Head and crest deep blue; back purplish blue (maximum amount of blue). *Hab.* Vera Cruz to Honduras. Var. *coronata*.*

2. Head and crest blue-black, strongly tinged with blue; back plumbeous-blue. (Intermediate form.) *Hab.* Central regions of Mexico. Var. *diadematа*.†

* CYANURA CORONATA var. CORONATA.
Cyanura coronata Swains, Phil. Mag., i, 1827, 437.
Hab. Eastern Mexico and Honduras. (North to Mirador and Xalapa.)

† CYANURA CORONATA var. DIADEMATA.
Cyanogarrulus diadematus, Bonap. Consp., 377.
Cyanura diad., Scl. Catal., 1862, 143.
Hab. Central table-lands and mountains of Mexico.

3. Head and crest deep black, scarcely tinged with blue; back ashy (minimum amount of blue). *Hab.* Rocky Mts. of the United States. Var. *macrolopha.**

B. No supraocular spot of white; greater wing-coverts not barred with black; chin and throat not abruptly lighter than the adjacent portions (*C. Stelleri*).

1′. Head, crest and anterior part of the body, above and below, sooty black; no blue on the forehead; the blue of a uniform indigo shade throughout (minimum amount of blue). *Hab.* Coast Mountains of North America, from Sitka to the Columbia river. Var. *Stelleri.*†

2′. Head, crest and anterior part of the body, above and below, plumbeous-umber often tinged with blue, the forehead conspicuously streaked with blue; the blue of two strongly contrasted shades, indigo on secondaries and tail, and azure on tail coverts, posterior parts of the body, and primaries (maximum amount of blue). *Hab.* The Sierra Nevada, from the Columbia river to southern California. Var. *frontalis.*‡

Like *C. Stelleri* var. *frontalis*, all the races of *C. coronata* have the forehead streaked, but with milk-white instead of pale blue. *Stelleri* var. *frontalis*, and *coronata* var. *macrolopha*, further agree in having the longest crests, most slender bills, and most contrasted shades of blue, in the whole series; while *C. Stelleri* and *C. coronata* (as restricted) have the shortest crests, stoutest bills, and most uniform blue. These parallelisms seem to be thus directly dependent at the same time on the nearness to, and remoteness from, the central forms. In the diagram,* represents the region where the two stocks intergrade, through the mixture of the two most melanistic races; the dotted line represents the parallel of the maximum development of the crest and attenuation of the bill, and contrasted shades of blue, with excess of neither black nor blue; while "A. 1" and "B. 1‴ represent the shortest crest and stoutest bill, and uniform shade of blue, with excess of blue on the one hand and of black on the other.

As a summary of these facts, it appears evident that the series of forms under consideration is divided into two well marked stocks, but that they intergrade at one point. The conclusion, then, must be that they are all modifications of one

* CYANURA CORONATA var. MACROLOPHA.
Cyanocitta macrolopha Baird, P. A. N. S., 1854, 118.
Cyanura m. Baird, B. A. Am., 1858, 582.
Hab. Central Rocky Mountains of the U. S.

† CYANURA STELLERI var. STELLERI.
Corvus Stelleri Gm., S. N., i, 1788, 370 (Sitka).
Cyanura s. Sw., F. B. A., ii, 1831, 495. App. (descr. but not fig., which is of the intermediate form between *Stelleri* and *macrolopha* !).—Baird, B. N. Am., 1858, 581.

‡ CYANURA STELLERI var. FRONTALIS.
Cyanura Stelleri var. *frontalis* Ridgway.

primitive species, or we must accept as the only alternative the hypothesis of hybridization. The latter theory, as an explanation of the intergrading of apparently distinct species, is fast losing favor with ornithologists who investigate deeply into the relationship of species, and may in this case, perhaps, well be abandoned.

ART. V.—*On the Experimental Determination of the relative Intensities of Sounds; and on the measurement of the powers of various substances to Reflect and to Transmit Sonorous Vibrations;* by ALFRED M. MAYER, Ph.D.

(Read before the National Academy of Sciences, in Cambridge, Nov. 21, 1872.)

WHILE the problems of the determination of the pitch of sounds and the explanation of timbre have received their complete elucidation at the hands of Mersenne, Young, De la Tour, König and Helmholtz, the problem of the accurate experimental determination of the relative intensities of given sonorous vibrations has never been solved.

The method I here present will, I hope, open the way to the complete solution of this difficult and important problem; and I trust that the success I have met with will instigate others, more learned and patient, to attack with superior acumen a subject which must necessarily become of fundamental importance in the future progress of acoustic research.

1. *The determination of the relative intensities of sounds of the same pitch.*

If two sonorous impulses meet in traversing an elastic medium, and if at their place of meeting the molecules of the medium remain at rest, it is evident that at this place of quiescence the two impulses must have opposite phases of vibration, and be of equal intensity.

I have, in the following manner, experimentally applied this principle to the accurate determination of the relative intensities of vibrations giving the same note, and propagated from their sources of origin in spherical waves.

Clothe two contiguous rooms with a material which does not reflect sound, and place in each room one of the sounding bodies, and maintain these sounds of constant intensity; or the two sources of sound may be placed in the open air, and separated from each other by a non-reflecting partition. Fix at a certain distance from each sounding body a resonator responding to its note, and attach to each resonator the same length of firm gum-tubing; then lead these tubes to a forked pipe, so that the impulses from the two resonators meet at the confluence of the two branches of the forked tube, and connect the branch of

the forked tube, in which the sounds meet, with one of König's manometric capsules. Now sound continuously one of the bodies, and the manometric flame when viewed in a revolving mirror will present its well known serrated appearance. On sounding the second body impulses from it will meet those from the first body, and if the phases of vibration of the impulses on the manometric membrane are opposed and of equal intensity, the membrane will remain at rest and the flame will now appear in the mirror as a band of light with a rectilinear upper border. But although the intensities of the pulses can easily be rendered equal by altering the distance of one of the resonators from its sounding body, yet this change of position will alter the relation of the phases of the impulses reaching the membrane, so that, if by mere chance, we get them opposed in the first position of the resonator, they will no longer be so after its change of position. But on stopping the vibrations of one of the bodies and setting it in vibration at intervals we may finally succeed in causing the impulses on reaching the membrane to have opposite phases of vibration. Such a method, which relies only on chance, can be of little value on account of its uncertainty and the tediousness of its application.

The above difficulty I have entirely removed by the following means. I cut a piece out of one of the tubes equal in length to a half-wave of the note we are experimenting on, and replace this piece of tubing with a glass tube of the same length, into which slides another glass tube also of half a wave in length. Now the experimentation becomes expeditious and certain. Sound both bodies continuously and place in a fixed position one of the resonators. Move the other to a certain distance from its sounding body and then pull out the inner glass tube until exact opposition of phase of the impulses is brought on to the manometric membrane. This condition will be known when the serrations have dropped to their minimum of elevation. If the latter do not entirely disappear from the band of light in the mirror, we must place the movable resonator at another distance and readjust the sliding tube. A few trials will give in the mirror a band of light with a straight, unruffled top border; then we have opposed phases of vibrations at the confluence of the branches of the forked tube, and equally intense pulses are traversing the two tubes leading from the resonators.

The distance of each resonator from its sounding body is now measured, and the inverse ratio of the squares of these distances will be the ratio of the intensities of the vibrations at the sources of the sounds, *if* the intensities of the impulses sent through a tube from a resonator varies directly with the intensities of the vibrations of the free air in the plane of the mouth of the resonator.

It will be observed that the accuracy of the determinations by this experimental method depend on three conditions. First, that the vibrating effects of the same area of a spherical sonorous wave diminish in intensity as the reciprocals of the squares of the distances of this area form the point of origin of the wave. There is every dynamic reason to believe in the truth of this proposition. The second necessary condition is that the elongation of one of the resonator tubes over the other by half a wave-length of firm glass tubing does not diminish the intensity of the impulses which have traversed it. Numerous experiments, especially those of Biot and Regnault on the aqueduct pipes of Paris, show that this short connecting tube of glass cannot in any way affect the accuracy of the measures. The third condition is that the intensities of pulses sent through a tube from a resonator vary directly with the intensities of the vibrations of the free air in the plane of the mouth of the resonator. This is a very important consideration, and as I believe there is no entirely reliable discussion of the above relation, the problem will have to be experimentally solved with the greatest care. If, however, the relations between the intensities of pulses inside the tube and those outside the mouth of the resonator shall be shown to be different (and I think they will be) from what we, for illustration, have here assumed, the process of the numerical reduction of the experiments will be only modified while the experimental method remains secure. Indeed, I cannot but consider that I have here, by applying the principle of interference, so fertile in results in optics, been the first to give an experimental method which will determine with precision the relative intensities of two sonorous vibrations producing the same note.

Savart and many other experimenters have determined the relative intensities of two sounds by placing sand or other light particles on membranes and receding from the source of sound until no motions of the particles were visible. Also Drs. Renz and Wolf (Pogg. Ann., vol. clxxiv, p. 595) give the results of experiments on the determination with the ear of the intensity of the sounds of a ticking watch. More recently Dr. Heller (Pogg. Ann., vol. ccxvii, p. 566) has made an elaborate research on the intensities of sounds; deducing mathematically his determinations from the observed amplitudes of vibration of a membrane; and Mr. Bosanquet (L. E. and D. Phil. Mag., Nov., 1872) has just published a paper in which he proposes to measure the intensities of the sounds of pipes of different pitch by the determination of the quantity of air which each pipe consumes in sounding. But all of these experimenters acknowledge the want of precision in their measures and the difficulties in the actual practice of their methods.

(To be concluded.)

ART. VI.—*On the Quartzite, Limestone and associated rocks of the vicinity of Great Barrington, Berkshire Co., Mass.;* by JAMES D. DANA. With a map.

[Continued from vol. iv, p. 453.]

2. *From the Housatonic valley westward.*

We might naturally suppose that the succession of strata in Monument mountain—gneiss, quartzite, gneiss, quartzite, in ascending order, and 800 to 1,000 feet thick (vol. iv, p. 450)—would be found to characterize the formation above the Stockbridge limestone elsewhere in Berkshire, and at least in the half a dozen miles square north of Great Barrington. But the facts now to be stated show that within a small part of this small area, the lower mica schist is in one direction replaced by quartzite; the lower quartzite, in another direction, by mica slate; and all the quartzite, mica schist and gneiss of the mountain, in another direction, by mica slate and chloritic mica slate, some of it dotted with magnetic iron. In the facts it is further shown that within a mile to the north of an east-and-west synclinal fold, there is a change from the one fold to two synclinals and an anticlinal; that several isolated north and south ranges of limestone are anticlinal emergences of a single burrowing wide-spread stratum or formation; and that some, if not all, of the high ridges of nearly vertically inclined mica slate, like that of Tom Ball, are synclinal folds of the slate.

In treating of the region "from the Housatonic valley westward," I present the facts by reference to five east-and-west sections in an interval of six miles.

West of the valley in the vicinity of Housatonic village, there are the following ridges and valleys (see map, repeated, with some emendations, in this volume): 1, the quartzite ridge W, and more to the west another, lettered L; 2, the Williamsville valley, continued south in Long Pond valley; 3, the Tom Ball ridge of mica slate; 4, 5, 6, the two limestone valleys of Alford separated by a mica slate ridge (Alford Ridge).

1. A section across the Housatonic valley just below the old furnace (*f* on the map) has been given in the left part of fig. 2, on page 452 of vol. iv. Figure 3 presents the same section, and in addition its continuation westward across the Williamsville valley and Tom Ball into Alford. It shows the anticlinal of the Housatonic valley (A^3), with limestone outcropping from beneath the schist that a few hundred yards farther south covers it (as represented in section 1), and the schist overlaid by the quartzite on both sides of the river. In Williamsville valley,

the limestone does not reappear; but instead, there is sufficient evidence that the overlying schist or slate is the upper rock under the alluvium of the river. The large masses of rock in sight are mostly boulders; yet some appear to be true outcrops, and if so indicate much variation in dip, with none at a high angle. In the slopes of Tom Ball, along this section, the slate of the lower part is nearly horizontal, or even westerly 15°, and some of it is calcareous; but forty yards above it changes to 40° to the eastward, with the strike N. 5° E.; and higher up to 50°–70°, and even 80° at the summit. The west slope of the mountain in this part is very precipitous.*

3.

Section from Monument mountain westward, south of *f*.

4.

Section from Monument mountain westward, north of *f*.

5.

Section from Glendale westward.

2. The section in fig. 4 was taken just north of the line of the old furnace, *f* on the map, or of the cross road *f'*. The first elevation west of the Housatonic is the ridge N, which is nearly a continuation of W; but while W consists of quartzite, about N the quartzite is wanting, and there are only the underlying beds of mica slate and limestone, a bluff of mica slate forming its summit—not over 150 feet above the river. The mica slate dips to the westward 25°. West of this ridge the section is essentially the same as No. 3, no limestone outcropping in its course, and the slate being probably the upper rock underneath the alluvium.

3. *a*. Half to two-thirds of a mile farther north in the Housatonic valley, near *b'* (map), the schist on the east (right) of the

* In figures 3, 4, 5, W shows the position of Williams river, and H that of the Housatonic river; and the height on the west (left) is Tom Ball ridge. The letter A indicates the position of anticlinals, and V of synclinals. The parts of the three sections over one another are on the same meridian on the map. The horizontal scale is to the vertical about as one to four.

limestone, so gently inclined near *f*, becomes nearly vertical, and the limestone adjoining has the same dip; but in the field to the westward the latter falls off in dip within 50 yards to its usual small amount, and farther west the beds disappear under the mica slate of Williamsville valley.

b. Again, half a mile farther north, near *b* on the map, the same schist, as represented at V^2 in fig. 5,* has the same nearly vertical position, the dip being 80° to 70° to the eastward and in part vertical; and the limestone adjoins it with an eastward dip of 70°, strike N. 2°–5° E. To the west of the brook, along the rising road, this limestone changes its dip to 62°, and strike to N. 15°–20° W.; then, at top of the ascent, to 40°, and in a few rods to 25° to the eastward, and strike to N. 40°–60° W., the northing in the dip increasing. At the top of the ascent there is a bluff north of the road which consists of mica slate resting on the limestone, both dipping northeastward and northward; and farther westward the limestone of the here declining Housatonic fold passes out of sight under the slate.

Continuing westward along the line of the section (fig. 5) into the Williams river valley, the limestone reappears through another anticlinal: and this is the first outcrop of the limestone in this valley north of Williamsville. It comes out from beneath the mica slate, dipping in opposite directions on the opposite sides of the river, on the east eastward 15° to 25°, and on the west, or Tom Ball side, southwestward at about the same angle. The slate is very much contorted on both sides of the valley, the zigzags being often a foot in breadth. The area of emerged limestone widens rapidly to the northward, and at F Q on the map is Freedley's quarry.

Following the line of the section westward (a little south of west), up the northeastern outliers of the Tom Ball ridge (really the eastern ridge of a north-and-south synclinal), the dip of the slate continues to be southwestward at a small angle, for half a mile or more. There is then a descent to a broad depression (*a* fig. 5) partly boggy at middle, which is without outcropping rock. Beyond this rises the northwestern summit, and upon it the dip of the mica slate is 75° to 80° *to the westward*, varying to vertical. The western slope of the ridge is covered with earth; but there are outcrops of limestone at the western foot, which show that the dip on that side is 45° to 50° to the eastward, the strike N. 10–20° E.

The limestone, besides widening northward, extends around the north end of the Tom Ball ridge, and continues southward

* In figure 5, the part above A^3 is represented too high in proportion to the height of the Tom Ball ridge to the west. The limestone A^2, between the two ranges of schist V^1, V^2, is at surface rather gently inclined for more than three fourths of its breadth.

uninterruptedly through the eastern valley of Alford and beyond, nearly encircling the mountain. Tom Ball ridge is thus cut off completely from the West Stockbridge ridge, half a mile of nearly level land, with outcropping limestone, intervening between their bases.*

The limestone in the northern part of the Alford valley has generally a strike of N. 10 to 20° E. (but at one place N. 8° W.), and an eastward dip of 45° to 50°; at the Churchill marble quarry (C Q, map), a north and south strike, with a dip of 90°, but a hundred yards north the dip diminishes to 40° to the eastward, and 300 south, to 30° and 35°; near Alford village, at one place the strike is N. 25° E.; at the south end of the valley N. 2° to 5° E. (but at one place N. 20° E.), the dip mostly 50 to 70°, though varying to 90°. The variations are such as occur in all the limestone regions, but less than usual, owing to the high inclination of the beds. At Churchill's marble quarry there is no division of the rock into layers through a thickness of 50 feet, while at the quarries north and south of it above referred to, where the dip is 30° to 40°, the layers are 1 to 6 or 8 feet thick. The great thickness at Churchill's quarry is owing to the soldering of many layers together, which took place at the time of metamorphism under the pressure producing the uplift and accompanying the crystallization. Such an obliteration of the layers when the dip is high is common throughout the limestone region of the Green Mountains.

Two important conclusions may be here stated.

I. The limestone of the Housatonic fold, A^3 in the sections, is the same stratum with that of the northern part of the Williamsville valley and that of Eastern Alford.

II. This limestone passes beneath the Tom Ball ridge, and the rock of this ridge is, therefore, an *overlying stratum, and has a synclinal position.*

c. The section in figure 5 extends eastward to Glendale. The mica slate V^2, already referred to (and which extends south along by *b'* and *b''* to the western side of Monument Mountain) has a width in this section of about 200 yards. The strike is N. 2° E. to N. 5° W., and dip 60° to 80° to the eastward. Next to the eastward comes limestone, A^2; first, with a steep eastward dip (60° to 70°) like the slate; but, going eastward 50 yards, falling off to 25° and 20°. Next, at *a* on the map, there is another range of slate, V^1, with nearly the same strike (N. 5° to 10° W.), and a high dip (50° to 70°). The limestone west of it (A^2) is conformable at the junction. To the eastward there is another and more extensive range of limestone (A^1), that of

* The latter ridge commences at D (see map), and its line is a more western one. The mica slate of the ridge is the same with that of Tom Ball, and is similarly seamed with quartz; the strike at D is N. 20°–25° E., and the dip 40°–45° E.

Glendale, which continues uninterruptedly eastward to Stockbridge; it adjoins the slate west of it (V^1) conformably; it loses its steep dip and becomes undulating over the Glendale and Stockbridge region, dipping variously but generally at a small angle to the eastward.

The slate V^1, just west of Glendale, whose position is indicated by *a* on the map, continues southward, crossing the Housatonic at the northwest bend in the river; and, with the limestones A^1 on its east side and A^2 on the west, constitutes a ridge, *a'*, which stretches southward to Monument Mountain, stopping at the elevated plain (200 feet or more above the river) of Smith's farm (*Sm* on the map). The strike of the mica slate at the bend is N. 20° W., varying, on going westward, to N. 10° E., with the dip 70° to 80° to the eastward; the western part is very rusty and decomposing.

Now near the Old Furnace (fig. 3) the limestone A^3 goes beneath the mica slate V^2, at a small angle. This limestone hence must go beneath this more steeply dipping schist, since it is a continuation of V^2, and it must emerge to the eastward either in the limestone A^2, or in A^1. But the nearly vertical dips of V^2 and V^1 (fig. 5), and the conformable yet mostly small-dipping limestone over the intermediate region, show that V^2 and V^1 are independent synclinals, and therefore that the limestone is all one and the same stratum rising in a series of anticlinals, as illustrated in the section.

Following the limestone A^2 south to Monument Mountain it appears finally to pass *beneath* the schist, though the covering of soil prevents a satisfactory examination of the junction.

In the steep slope rising above the Smith farm plateau on the south, the schist, where it outcrops, dips *westward*, which is unusual in Monument Mountain, and is apparently connected with the synclinal of mica slate that here commences. Upon this plain in the schist (near I, map) there are two very thin local beds of limestone; and one is overlaid by a local bed of quartzite a few yards thick. This is the only quartzite observed between the region of limestone about the ridge *a'* and the rocks of Monument Mountain.* The plain which is at the top

* North of the section represented in fig. 5, in the direction of V^1, a few hundred feet north of *a* (see map), there is a steep ridge of mica slate, which is the southern outlier of the Lenox Mountain range—a line of heights between West Stockbridge and Richmond on the west and Lenox on the east, and terminating in southern Pittsfield. The dip of the slate of the ridge is mainly to the eastward at a large angle, as in Tom Ball, though 70° to the westward at this south end. The limestone of West Stockbridge in the outcrop nearest the ridge dips conformably beneath it, while 50 to 100 yards west of the slates the dip of the limestone is generally very small (25° and less) and very various as about Glendale. Lenox Mountain is probably the course of a synclinal, like the ridge *a a'* in which it seems to begin, and like Tom Ball.

of the slope (from which the steeper part of the mountain rises) is 80 or 90 feet above the Smith farm plain.

The range of steeply dipping schist, V^1 (fig. 5), which near Glendale has about the same width as V^2, is not 50 feet wide (between the steeply inclined limestones A^1, A^2), at its termination just north of Smith's farm (*Sm* on map); which shows that the fold V^2 is pinched out as it nears the mountain.

From the above facts we have good grounds for the following additional conclusions.

III. The limestone of Eastern Alford, of the north end of Williamsville valley about Freedley's quarry, of the Housatonic valley, and that of Glendale and Stockbridge all belong to one stratum. Moreover, this same stratum of limestone extends from the Freedley quarry region (F Q on the map), at the north end of Tom Ball ridge, without break, I believe, *north* to West Stockbridge, three miles distant in the same Williams river valley;* and thence farther north, as I know from observation, through Richmond to Pittsfield; and also *south* from Alford into Egremont and Canaan. It is evidently one continuous mass.

IV. While in Monument Mountain there is a single broad uplift of the rocks, there are, directly north of it within a mile (section in fig. 5), two steep synclinals of mica slate; and this mica slate is part of the Monument Mountain formation.

V. In the synclinal V^2 (figure 5) the folded stratum of mica slate is a little less than 300 feet thick, since the whole breadth is 200 yards and the dip nearly vertical; and this directly overlies the limestone. Now near the Old Furnace on the Housatonic river the thickness of the mica slate over the limestone is only 50 or 60 feet; and this is overlaid in Monument Mountain by 200 or 250 feet of quartzite; and, above this, 300 feet at least of mica schist and gneiss; and then higher up another thick stratum of quartzite. Therefore, in the short distance of a mile and a half, the lower quartzite of Monument Mountain, q^1, 200 to 250 feet thick, has wholly disappeared, and instead of it there is mica slate. This quartzite, to the northward, even before reaching the line of the Old Furnace, is mostly well bedded, and although mainly concealed by soil; shows evidence of thinning in that direction.

VI. In the section in fig. 5, at its west end, the quartzite of Monument Mountain, q^1, overlying the schist and limestone near the Old Furnace, would naturally be looked for in the rocks of the Tom Ball ridge above the limestone. But it does not exist in any part of the slopes, nor does it outcrop to the south, except at the southern end of the ridge. Hence again

* On the map the roads terminating at W S lead to the village of West Stockbridge, and that at C to the village of West Stockbridge Center, west of the West Stockbridge ridge.

the quartzite stratum has little persistence in any direction. Its representative in this region, when absent, is mica slate.

VII. Only 300 feet of the Monument Mountain formation are folded up in each of the folds V^2 and V^1 in the section represented in fig. 5. This was probably because these folds are so small, the overlying beds having been rejected, broken up, and carried off. Two synclinals and an anticlinal are comprised within a breadth of only two-thirds of a mile.

VIII. Steep *synclinals* of slate, when the slate is associated with a thick stratum of limestone and is the *overlying* rock, should make ridges; and *per contra*, steep anticlinals if the slate is the *underlying* rock. In both cases, to produce an enduring ridge, the slate should be folded on itself so as to make a common mass; and this is not the case in an anticlinal with limestone beneath, or in a synclinal with limestone above. Hence it is that the mica slate ridges of this part of Berkshire, where nearly vertical in dip, are mainly, if not wholly, *synclinals*. The mica slate is the *overlying rock*.

IX. The mica schist and gneiss of Monument Mountain, and of regions east and south, are represented, even in the northwest part of this mountain, and in all the ridges of the region north and west of it, by the smooth mica slate (see p. 366 of vol. iv.), which is often garnetiferous, and sometimes chloritic, or dotted with magnetite. In other words, in the *same stratum* the crystalline character is most decided to the east and south; and the hydrous character (chlorite as well as the hydro-micas being hydrous minerals) most decided to the west and north.

Two more sections across this western part of the Great Barrington region remain to be described.

[To be continued.]

ART. VII.—*Observations upon the Meteors of Nov. 24th–27th, 1872*; compiled by H. A. NEWTON.

THE meteors seen upon the evenings of Nov. 24th, 25th and 27th, from their numbers, and from their probable connection with Biela's comet, are of such interest and importance as to justify a minute record of observations upon them.

November 24th.

1. *In New Haven.*—On the evening of Sunday, Nov. 24th, about 7^h 35^m, Arthur T. Hadley, a student in Yale College, saw several meteors descend from the constellation Cygnus toward the western horizon. He called the attention of his uncle,

Prof. Twining, to the occurrence, and soon after Prof. Twining notified me. The appearance so early in November of the meteors supposed to be connected with Biela's comet had not been anticipated, and, therefore, they came upon us by surprise. Prof. Twining, previously to calling me, had made a rude approximation to the place of the radiant, considering it to be in the neighborhood of Andromeda's hand. Between half-past seven and a quarter-past nine his nephew counted 43 meteors. The actual time of watching was estimated as between 60 and 65 minutes.

The counting of the meteors was kept up with some interruptions till after midnight, with the following results.

From	8^h	15^m	to	8^h	30^m	P. M.	7	meteors, by	1	observer.
"	8	45	"	9	0	"	14	"	2	"
"	9	0	"	9	15	"	9	"	2	"
"	9	15	"	9	30	"	10	"	1	"
"	9	30	"	9	45	"	7	"	1	"
"	9	45	"	10	0	"	10	"	1	"
"	10	30	"	10	45	"	36	"	4	"
"	10	45	"	11	0	"	34	"	4	"
"	11	0	"	11	15	"	15	"	2	"
"	11	15	"	11	30	"	23	"	2	"
"	11	30	"	11	45	"	15	"	2	"
"	11	45	"	12	0	"	11	"	2	"
"	12	0	"	12	10	"	6	"	2	"
"	12	15	"	12	30	"	7	"	1	"

There was no moon, and the sky was tolerably clear. We could not command the parts within 15 or 20 degrees of the horizon because of trees and houses. Allowance in the numbers of the above table should also be made for the time I was occupied in laying down some of the tracks upon the chart.

About three-fourths of the flights were conformable to a radiant region near gamma Andromedæ. Several of the unconformable ones had a peculiar faint light, and a rapid motion, giving an impression as if a white object passed rapidly by us, a few yards distant. Had they been of a dark color I might easily have imagined them to be bats, or other flying animals. These radiated from the eastern heavens, perhaps from near Orion. They were also so like each other, and so unlike the ordinary meteors, that they must belong to a group by themselves.

The following tracks, laid down upon a chart by Arthur T. Hadley and myself, will help to locate the radiant, and determine its character. The place assigned to the center of the radiant area by me at the time was two or three degrees north of γ Andromedæ.

Beginning. R. A.	Beginning. N. Dec.	Ending. R. A.	Ending. N. Dec.	Obs.
343	54	315	53	H.
315	35	302	29	H.
15	37	10	34½	N.
18	46	13	50	N.
34	43	41	38	N.
42	39	47	38½	N.
50	25	54	20	N.
24	23	24½	16	N.
28	24	28	17	N.
60	78½	135	81	N.
320	66	265	60	N.
345	64	335	65½	N.
358	62	342	66	N.
355	20	350	11	H.

2. *In Bethlehem, Pa.*—The number of shooting stars, as is evident from this record, would not attract general attention, being only about 40 to the hour for a single observer. Mr. R. M. Gummere, of Bethlehem, Pa., however, noticed them, and counted 40 between 10 and 11 o'clock. They appeared to him to radiate from near the zenith. Three or four were quite brilliant.

November 25th.

3. *In New Haven.*—On the morning of Monday, Nov. 25th, I watched 15^m, and saw no conformable meteors. The sky was partially clouded, and the radiant low in the N.W.

On the evening of Monday, Mr. O. Harger and the writer watched from 7^h 40^m to 9^h. The haze and clouds interfered somewhat, yet we saw 28 meteors, of which we estimated 15 to be conformable to a radiant near Andromeda. It was quite evident that a part of those seen belonged to the same group as those of the previous evening.

Later in the evening Mr. Harger, assisted by Bouton, Nevins, Tillinghast and Torrey of the Sophomore Class in Yale College, watched 3½ hours with the following results. The recorded fractions expressing the amount of sky covered by clouds are considered by Mr. Harger as too small.

Time.				Conf. meteors.	Unconf.	No. of obs.	Cloudiness.	
From 10^h	25^m	to 11^h	0^m	7	3	4	½	sky covered.
11	0	" 11	30	11	4	4	½	"
11	30	" 12	0	6	5	3	¾	"
12	0	" 12	30				⅞	"
12	30	" 1	0	11	24	3	1	"
1	0	" 1	15				¾	"
1	15	" 1	45	4	5	3	all	"
1	45	" 2	0				¾	"
Total,				39 conf.	41 unconf.			

One-half of the meteors seen were, therefore, of the Andromeda group. On Sunday evening the proportion was three-fourths, implying a frequency on the earlier evening three-fold that on the later. This relative frequency is confirmed also by the absolute numbers seen.

A storm prevented further observation until Wednesday evening.

November 27th.

4. *In New Haven.*—On Wednesday evening the meteors were in such abundance as to constitute a true *star-shower*, even in Mr. Herrick's use of that word. He thought that the term should be reserved for occasions when at least 1,000 meteors per hour were visible.

A party of students upon the tower of Graduate's Hall, under my direction, began to count regularly at $6^h\ 38^m$ P. M. The periods in which fifty were counted, and the number of persons counting were as follows:

In 4^m	0^s	by 2 obs.	In 3^m	5^s	by 6 obs.	In 5^m	0^s	by 5 obs.
3	0	2 "	2	40	6 "	3	30	5 "
2	15	3 "	3	0	6 "	4	10	5 "
2	15	3 "	3	40	6 "	4	20	4 "
2	30	3½ "	3	10	6 "	3	50	4 "
1	30	4 "	3	40	6 "	5	5	4 "
2	30	4 "	2	50	6 "	6	5	4 "
2	15	6 "	3	10	6 "	6	45	4 "
2	30	6 "			6 "	3	45	4 "
2	35	6 "			6 "	9	0	4 "
3	30	6 "	15	0	6 "	7	30	4 "
2	25	6 "			6 "	Total, 1750 in $130\frac{1}{2}^m$.		

These numbers show a tolerably steady diminution in the frequency of the flights, there being 1000 in the first $56\frac{1}{2}$ minutes, and 750 in the last 74 minutes. Many others, not noticed by the persons counting, were seen by Prof. Twining and myself. These were not included in their numbers. They were looking in different directions, a portion of the sky being allotted to each observer. Toward the close of the above period ($8^h\ 48^m$), the haze had increased so as to interfere seriously. There was no moon.

After twelve o'clock I watched fifteen minutes. Through breaks in the clouds enough sky was visible to assure me that the display was essentially over.

Prof. Twining was with us the latter part of the time, and made the following notes upon the characters of the meteors and the place of the radiant:

"From the 'Tower' as a station, I observed from $7^h\ 33^m$ P. M. to $8^h\ 45^m$, giving attention to the apparent radiant, and the space on every side of it. I saw but one flight that was noticeable for length or brilliancy. This was about 12° long. It would

not have been remarkable in either the displays of August 10th or of Nov. 14th. The flights were frequent, but very short, slow-moving and faint. Near the radiant they were foreshortened, as usual; but still the apparent paths were so very short, that the absolute lengths of luminous track were evidently less than those of the usual periodic meteors. Within 10° of the radiant five tracks were observed from $\frac{1}{4}$° to $\frac{3}{4}$° long, and with a duration of $0^s{\cdot}3$ to $0^s{\cdot}5$ of time. The luminous lines were narrow, and often *unstable*, and not in well established right lines. The longest flight in duration was about $0^s{\cdot}7$, being not 5° long. Except in three instances the flights were from 1° to 4° in length, and $0^s{\cdot}3$ to $0^s{\cdot}6$ in duration.

"The position of the radiant was very well established. Its centre was about 43° N. Decl. and 25° R. A.; but the area of emanation seemed to be as much as 8° long. Its longer diameter was along a circle of declination and it was perhaps 3° in the cross direction."

Except to record the times and results of the counting, my own attention was confined to the determination of the place and extent of the radiant area. This was at least 8°, and was possibly 12° or more, in length, and the center of it was decided to be about 3° from γ Andromedæ in the line from the Pleiades through that star. It seemed to include the star, since in almost every direction there were flights from either side of it.* The extent was at least half as great north and south as east and west. It was difficult to determine the exact direction of the major axis of the area; I supposed it to have been nearly in the circle of declination.

The effect of the perpendicular course of the flights in shortening their real length was undoubtedly great. Those seen by me were also generally near the radiant, and thus greatly foreshortened. But the bodies, I am convinced, were really smaller, and would therefore in any case be more quickly consumed than the usual August and November meteors.

The only two trains which I placed upon the chart were—beginning, 25° R. A., 41° Dec.; end, 23½° R. A., 38° Dec. Beginning, 26° R. A., 44° Dec.; end, 26½° R. A., 48° Dec.

At the Sheffield Scientific School, Prof. Lyman and Mr. G. W. Hawes counted 64 meteors in six minutes between $5^h\ 55^m$ and $6^h\ 1^m$, P. M.; Mr. T. M. Prudden and Mr. Hawes counted 67 in 12 minutes, between $7^h\ 35^m$ and $7^h\ 47^m$. In 12½ minutes, between $7^h\ 47\frac{1}{2}^m$ and 8^h, these three gentlemen counted 81, and between $8^h\ 4^m$ and $8^h\ 21^m$, or in 17 minutes, they saw 100. Prof. Lyman placed the center of the radiant at R. A. 25° and N. Dec. 43°. He remarked that it was most obviously scattered.

In 5 minutes near 6^h P. M., Mr. C. W. Chapman, who was at my house, counted 30 flights. Another observer, viewing

* Prof. Twining says that it did most certainly include the star.

part of the sky, counted 50 meteors between $7^h\ 35^m$ and $7^h\ 56^m$. On Thursday I saw no meteors in 15 minutes between $5\frac{1}{2}^h$ and 6^h, P. M. On Friday, from $8^h\ 53^m$ to $9^h\ 8^m$, P. M., I saw 3 meteors in a clear sky, neither coming from Andromeda. On Saturday, from $5^h\ 40^m$ to 6^h, A. M., I saw 8 flights in the eastern sky, three of which might have come from Andromeda, then in the N.W. Four were from near the zenith, perhaps from Leo.

5. *In Washington.*—The following report of Rear Admiral Sands to the Secretary of the Navy, is copied from the N. Y. *Herald*:—"I have the honor to report that last night, being clear, a fine display of meteors was observed by Professor Eastman and Mr. Horrigan, watchman of the observatory. In the early evening, Professor Eastman being occupied in other duties, Mr. Horrigan observed 485 meteors between $6^h\ 15^m$ and 8, P. M. From 8^h to 9^h, P. M., Professor Eastman observed part of the time, and 131 were seen; after 9^h, P. M., 100 more were seen, and at 10^h, P. M., the display seemed to cease. The maximum flight appears to have been between the hours of $6^h\ 15^m$ and $6^h\ 30^m$, reaching an hourly rate of 102 in 15 minutes, and of 400 in 8 minutes. Mr. Horrigan saw 10 before he commenced the above record, making the whole number observed 720. They appeared to radiate, by Professor Eastman's observation, from a space which might be enclosed by a circle of eight degrees in diameter, having its center at μ Andromedæ. Professor Harkness also observed, but differs a little as to the point of radiance, placing it about half way between μ and γ Andromedæ. As there was but a single observer in the early evening, whose attention was confined to one portion of the heavens, there were probably four and a half times as many fell as were observed. According to Professor Harkness' observations, the most of the meteors were about of the fourth magnitude. The color to the naked eye was generally faint blue, but some of the larger were reddish. The tracks were generally very short, not exceeding from four degrees to six degrees. The average time of flight was from one to two-tenths of a second. Professor Eastman succeeded in catching the spectra of two small ones. The first had a faint continuous spectrum with an excess of yellow or greenish yellow; the second had a faint green spectrum, the first glimpse of which appeared perfectly white. They were both very faint and moved rapidly. This display is a very remarkable one, and exceeds that ordinarily seen on the 14th and 15th of November. The radiant point seems to indicate that they are moving in the orbit of Biela's comet."

6. In a letter to the editors, Prof. A. Hall, of Washington, reports the following observations.

From $6^h\ 25^m$ to $6^h\ 43^m$, Washington mean time, one hundred meteors were counted, and from $7^h\ 40^m$ to $8^h\ 0^m$, fifty were counted. Most of the meteors were small, and only four or

five near the zenith left trails that endured a few seconds. The sky was clear to within 10° or 15° of the horizon. By a rough estimation, from a few of the tracks traced upon a globe, the radiant was located at R. A. 355°, Dec. +43°.

From this position of the radiant, Prof. Hall computed the following parabolic orbit by the formulas of Dr. Weiss.

Elements of Meteors.	Biela's Comet.
$\pi = 89°.5$	$\pi = 109°.0$
$\Omega = 246°.1$	$\Omega = 245°.9$
$i = 15°.4$	$i = 12°.6$
$log\ q = 9.976$	$log\ q = 9.935$

7. Prof. S. Newcomb also writes to the editors as follows:

"This evening between $6^h\ 50^m$ and 7^h, W. M. T., meteors fell at a mean rate of perhaps 15 or 20 per minute. During the few minutes I watched, my attention was given to the region near the radiant point for the purpose of fixing the position of the latter. It was quite near the star 50 Andromedæ, probably a degree or so to the northeast, which would make its position

R. A. $1^h\ 32^m$ Dec. $+ 41\frac{1}{2}°$.

The uncertainty of this position I suppose to be about 2°. At $7^h\ 20^m$ the frequency had diminished so rapidly that it was no longer possible to estimate the position of the radiant with precision. This accidental opportunity to determine it may therefore have been fortunate enough to warrant the publication of its result."

8. *In Rochester, N. Y.*—Mr. Lewis Swift, in Rochester, N. Y., counted in an hour and a half, between 9^h and 11^h, P. M., 51 meteors. All but one radiated from γ Andromedæ, or more exactly from a point about one fourth the distance from γ to β. At the beginning of his observations the radiant was exactly at γ, but at the end was as stated above. They were mostly small and moved more slowly than ordinary meteors.

On the next evening (Nov. 28th) the sky was clear, but there were no meteors.

9. *In Philadelphia, Pa.*—Mr. B. V. Marsh, on Wednesday evening, about 10 minutes after 6, counted 11 meteors in a minute or two. He then kept watch for an hour or two with the following results:

From	$6^h\ 15^m$	to	$6^h\ 30^m$	50	meteors,	or 200	to the hour.
"	6 30	"	6 45	38	"	152	"
"	7 10	"	7 30	40	"	120	"
"	7 50	"	7 58	12	"	90	"
"	11 30	"	11 45	3	"	12	"
			Total,	143			

He adds: "I presume that the maximum had passed before I commenced my count, as there was a steady diminution in the hourly rate, and I am confident that the interval during which

I saw the first 11 did not exceed two minutes, giving an hourly rate of 300.

"The radiation was diffuse. The principal radiant I thought was about R. A. 15°, Dec. + 30°. The radiant space was very large, and seemed to me oblong—say 50° by 37°. The space which I marked upon the globe was enclosed in an ellipse having its axes terminating as follows:

Major axis from R. A. 347°, Dec. +20°, to R. A. 42°, Dec. + 40°
Minor " " 5° " 47°, " 16° " 12°

"Of course these figures cannot make claim to much accuracy, but I record my impression, noted at the time. I also noted as follows: paths short—not many over 5°; color of larger ones yellowish; velocity moderate; paths of 3 or 4 appeared wavy; brilliancy quite moderate, few if any equal to a star of 1st mag.; some few with trains, but *none* of them *persistent*. On Thursday and Friday evenings not a meteor was to be seen."

10. *In Haddonfield, N. J.*—Mr. W. C. Taylor, of Philadelphia, writes: "From the numbers seen by myself, and several members of my family, I am satisfied that 20 per minute (for 5 observers) is a safe estimate of their frequency at seven o'clock Supposing that, as with the earlier meteors of this month, the display would intensify as the night advanced, I did not keep a continuous watch at this time. Toward eight o'clock our sky became partially overcast, but there remained visible enough of the heavens to show that the number of meteors had greatly lessened. At ten o'clock the intervals averaged about 30 seconds for one observer. At two o'clock this (Thursday) morning, in two short watches, I saw not a single meteor."

"I have been an observer of the November meteors for many years, but never, except on one occasion, saw them so abundant as they were early last evening. I can name no better radiant than γ Andromedæ."

11. *In Oxford, Conn.*—Mr. O. Harger was on the road to Oxford at 6^h, P. M., Wednesday. In what he estimated as 10 minutes he counted, alone, 100 meteors. The period included the time of striking the hour *six*.

From 8^h 3^m P. M. to 8^h 22^m, he and his brother counted 100 meteors.
" 8 22 " 8 39 " " 50 "
" 9 16 " 9 27 " " 11 "

12. *In Indiana.*—At Greencastle, Ind., Prof. Tingley counted 110 in 40 minutes, at a time not later than 7^h 55^m, P. M. At Princeton from 7^h 45^m to 8^h 15^m, P. M., Mr. Hunter and others in one half of the sky saw 70.

Remarks upon the Display.

Dr. Weiss, of Vienna, who first pointed out in 1868,* the probable connection between Biela's comet and the meteors seen

* Sitzungsberichte, vol. lvii.

Dec. 6th, 1798, by Brandes, and Dec. 6th, 1838, by Mr. Herrick, gives the radiant for meteors following the path of that comet, as R. A., 23°·4, N. Decl., 43°·0. I assigned a point 3° from γ Andromedæ as the center of the radiant of the meteors, or about R. A. 25°·3, N. Decl., 43°·3. The longitude of the node of Biela's comet was in 1852, according to Hubbard, 245° 51′, and the comet would pass about a million of miles from the earth's orbit, between it and the sun. We passed that place of the node early Wednesday evening, Nov. 27th. There can hardly be a doubt therefore that these meteors were once fragments, or companions, of that comet.

Any theory that shall explain the formation of the present grouping of meteoroids must account for the magnitude and shape of the radiant areas. If the members of a group have nearly the same orbit, the radiant should be a point. But the area of the radiant, Nov. 24–27th, was at least 8° long. This implies that the orbits differ considerably, either,—(*a*) in their inclinations to the ecliptic; (*b*) in their major axes; (*c*) in the longitude of perihelion; or, in two or three of these elements combined.

The shower ended abruptly Wednesday evening, and in the clear evenings that followed nothing special was to be seen. Similarly marked limits are not uncommon in other showers. The orbits must then either lie approximately in a plane or there must be a common node in the ecliptic, where the earth meets them. Such a node would point unequivocally to the earth as the body that originally scattered the comet.

If, as seems more probable, the orbits, however, lie nearly in one plane, either the major axes, or the longitudes of the perihelia, must differ widely. Neither of these conditions could be satisfied, so far as I can see, by a group formed from the dispersion of a comet by Jupiter, or other large planet. If the fragments of the comet leave the neighborhood of Jupiter, they should after each revolution return nearly to the same point in space. But a radiant area 8° or 10° long on the night of Nov. 27th, implies a distribution of the aphelia over 10° or 12° of longitude, or a similarly large difference of major axes. Such orbits can hardly have a common point at a great distance from the sun. Moreover, a scattering accomplished in a short time upon a body moving in an orbit inclined several degrees to the ecliptic should, it would seem, be incompatible with a grouping at the earth's node.

Again, suppose a disrupted body or agglomeration, has been once changed into a stream by the differential action of gravitation in the manner shown so beautifully by Schiaparelli. If the perturbing forces exerted by any planet or planets, whether temporary or long continued, should produce such differences

of major axes, or longitudes of perihelia, by *differential* action, the total action would, undoubtedly, entirely scatter the group at the earth's nodes.

In fact, instead of regarding the meteors as a stream we ought rather to look upon the group as coming together near the perihelion,—or near the node,—and then scattering widely, to reassemble, perhaps, after a complete revolution in the orbit.

A resisting medium cannot account for the observed effect, for this does not change the longitude of the perihelion of an orbit.

It seems to me, therefore, that the periodic meteors cannot have been brought into the solar system as a stream, but that the forces which have scattered the comets are those acting near the perihelia of their orbits. As a probable corollary, we may infer that whatever force divided Biela's comet into its two principal parts was one acting near the perihelion.

If we consider the orbits of the meteors of Nov. 14th, the preceding discussion is simplified. That shower is sharply limited, being in its greatest intensity only one or two hours long. Its recurrence at regular intervals of one-third of a century, for nearly a thousand years, precludes great differences of the major axes of the individual orbits, and the secular procession of the node of the group, *as a group*, equally forbids great differences of inclination of the orbits.

The size of the radiant is therefore due almost exclusively to the difference of the longitudes of the perihelia. This difference for that group cannot be less than 15°.

In conclusion I would say that we have no evidence, as yet, that any radiant of meteors is so small as is apparently required by the supposition of the distinguished Italian astronomer, that the meteors were drawn as a stream into the solar system from the stellar spaces. With Prof. Weiss and others, I am inclined to consider them all to have been once connected with periodic comets. The scattering took place apparently at or near the perihelion.

ART. VIII.—*Discovery of a new Planet;* by JAMES C. WATSON. (From a communication to one of the Editors.)

ON the 25th inst. at $7^h\ 30^m$ I discovered in Taurus a planet hitherto unknown. It is large and bright, resembling a star of the 9th magnitude. The unfavorable state of the weather has prevented me from obtaining any observations later than the 26th. The following are the places observed:

1872. Ann Arbor m. t.				α			δ		
Nov. 25,	9^h	49^m	31^s	4^h	21^m	$44^s{\cdot}92$	$+19°$	34′	$16''{\cdot}2$
25,	10	21	51	4	21	43·44	19	34	19·9
25,	10	47	14	4	21	42·65	19	34	18·0
26,	11	9	4	4	20	40·72	+19	34	39·7

Observatory, Ann Arbor, Nov. 30, 1872.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Tests for certain Organic Fluids.*—In his investigations connected with the ammonia process of water-analysis, Wanklyn observed: (1) that when an animal fluid is mixed with an excess of potash, evaporated down in contact with the alkali, and maintained at a temperature of 150° C. for some time, it evolves a certain fixed proportion of ammonia; (2) that after this, a further quantity of ammonia may be obtained by boiling the residue with potassium permanganate in alkaline solution. He also observed that, for certain animal fluids, not only is the total quantity of ammonia obtained characteristic, but the relative amounts yielded by the two processes given are so also. This fact, Wanklyn thinks, will be of value in practical biology and medical jurisprudence. For example, he has proved that urine yields a large proportion of ammonia to potash (the only fluid that does so), and a small quantity to permanganate; milk yields half as much to potash as to the permanganate; blood yields one-fifth as much; moist white of egg about one-fourth as much; gelatin gives no ammonia (or only the least trace) to potash, but a good quantity to the permanganate. In the experiments, 5 c.c. of the animal fluid were diluted to 500 c.c., and 5 or 10 c.c. taken for each analysis. The liquid was heated in a minute retort connected with a small Liebig's condenser, on an oil bath; and the ammonia determined by Nessler's test. By this process, it is possible to distinguish satisfactorily between a spot of milk and one of white of egg upon a cambric handkerchief.—*Jour. Chem. Soc.*, II, x, 645, August, 1872. G. F. B.

2. *On the Transformation-products of Starch.*—The results of the action of malt-extract upon starch, as given by different authors, being discrepant, O'Sullivan has reinvestigated the subject, examining both of the products, (1) the dextrin and (2) the sugar. For the preparation of the former, 100 grams air-dried starch were stirred up with 300 c.c. of water at 40° and the mixture poured into 2 liters of boiling water. After the paste had cooled to 70° C., the cold extract from 20 grams pale malt was added to it. When the solution was no longer colored by iodine, it was boiled, cooled, filtered, evaporated to 300 c.c., and precipitated by alcohol. Similar quantities of paste were transformed by the action of sulphuric and of oxalic acids. The white, waxy mass, even after 30 precipitations, still retained the power of reducing cupric oxide to the extent of 8 or 9 per cent. of dextrose. To eliminate this reducing body, the dextrin solution was submitted to fermentation, and again precipitated by alcohol, three or four times. It was finally washed with alcohol, thrown on a filter, pressed in bibulous paper, and dried over sulphuric acid. Eight preparations made by these general methods, modifying

only the details, gave products remarkably uniform in character and composition, but still retaining a reducing power equal to nearly two per cent. dextrose. Pure dextrin thus obtained is a brittle white powder, showing shining fracture-surfaces, easily soluble in water, not perceptibly so in cold alcohol of sp. gr. 0.82. An aqueous solution, containing 10 grms. in 100 c.c., has a sp. gr. 1.0385. Its specific rotatory power is $[a] = +213°$. Dried over sulphuric acid, the weight becomes constant when it contains 9.5 to 10 per cent. of water. This it loses in a current of dry air at 100°. Analysis of the dextrin dried over sulphuric acid gives the formula $C_6H_{10}O_5 + H_2O$. Treated with malt-extract its solution increases in reducing power, and becomes constant when the amount of sugar present, calculated as dextrose, is equal to 66 per cent. of the dextrin employed. The specific rotatory power is then $[a] = 150°$. To study the sugar produced, a starch paste, made as above, was treated with the extract from 20 grams pale malt, and the mixture allowed to stand at 40° to 45° for three hours. It was boiled, cooled, filtered, evaporated to 300 c.c., boiled with 2 liters of alcohol (sp. gr. 0.82), cooled, the alcohol decanted and set aside. In six days the sides of the vessel were covered with a crystalline crust. Five other preparations of this substance were made, some from the mother-liquors, others by dialysis and reprecipitation. The products were all alike, had a specific rotatory power $[a] = +150$, and reduced copper oxide equal to 65 per cent. glucose. Analysis gave numbers agreeing with the formula $C_{12}H_{22}O_{11}$. The author believes, therefore, that the end-product of the action of malt-extract upon starch is a sugar analogous to lactose, which has a reducing power only two-thirds as great as dextrose, and which appears to be identical with Dubrunfaut's maltose.—*Jour. Chem. Soc.*, II, x, 579, July, 1872. G. F. B.

3. *On Dextrin.*—Considering dextrin as the result of the union of two molecules of dextrose by the elimination of one molecule of water, Musculus has attempted its synthesis. By solution of dextrose in sulphuric acid, sulpho-dextrosic acid was obtained. Instead of breaking this up by heat, as in the ordinary etherification process, Musculus dissolved it in alcohol of 95 per cent.—in which dextrin is insoluble—filtered the solution, and placed it aside. The next day a slight precipitate appeared, which increased daily for three weeks. The supernatant liquid was decanted; the precipitate, washed free from sulphuric acid by alcohol, was dissolved in water and evaporated to dryness. A dry, friable, and almost colorless amorphous mass was obtained, which had no sweet taste, was very soluble in water, insoluble in alcohol, did not reduce the copper test, was saccharified feebly by diastase, not colored by iodine, converted into dextrose by heating with dilute sulphuric acid, and having a rotatory power nearly double that of dextrose. Agreeing in all except the last particular, closely with dextrin.—*Bull. Soc., ch.* II, xviii, 66, July 15, 1872. G. F. B.

4. *On the existence of an inferior Homologue of Benzol.*—Kekulé's theory of the hexacarbon nucleus of aromatic compounds forbids the existence of an inferior homologue of benzol. The announcement of Carius that he had obtained pentene C_5H_4, which would be such a homologue, is of so much importance that the question of its true character should be at once determined. ROMMIER has submitted, therefore, the lightest products of coal-tar to examination, with a view of detecting pentene. The first product isolated was a small quantity of an oil boiling between 40° and 50°, which had the density of water and consisted of nearly pure carbon disulphide. A second product, boiling from 58° to 62°—pentene, according to Carius, boiling at 60°—after the separation of the CS_2, was nitrated, and yielded a compound identical with binitrobenzol. Pentene has no existence in coal-tar, therefore.—*Bull. Soc. Ch.*, II, xviii, 70, July 15, 1872. G. F. B.

5. *On the Synthesis of Orcin.*—Orcin, discovered by Robiquet in 1829, is the basis of the coloring matter of lichens. It is a homologue of resorcin, and has the formula $C_6H_3\begin{cases}CH_3\\OH\\OH\end{cases}$ VOGT and HENNINGER have succeeded in producing it synthetically. By the action of chlorine upon toluol containing a little iodine, chlortoluol, boiling between 157° and 159°, was obtained. This, heated with two or three times its weight of sulphuric acid, yielded a thick brown liquid containing two isomeric acids named respectively α and β chlorocresylsulphurous acids. They were separated by the greater solubility of the barium salt of the latter. The α chlorocresylsulphite of potassium obtained from the barium salt, was fused in a silver capsule with twice its weight of potassium hydrate. Hydrogen was disengaged, and, after cooling, the mass was dissolved in water, acidulated with hydrochloric acid, agitated with benzol to remove small quantities of salicylic acid and cresylol formed in the reaction, and then with ether to dissolve the orcin. After removal of the ether by distillation, a brown syrupy residue was left which was dissolved in water, filtered, evaporated to dryness in a current of carbonic gas, and distilled in vacuo. A yellow, thick liquid passed over between 185° and 190°, which solidified on cooling. This, on solution in water and recrystallization either from water or chloroform, gave crystals of pure orcin, identical in all its properties with the natural product.—*Bull. Soc. Ch.*, II, xvii, June, 1872.

G. F. B.

6. *On a simple method of determining Molecular Weights from the Vapor Volume.*—Instead of ascertaining the absolute vapor-density, now of little use, LANDOLT proposes to determine only the relative vapor-density. Inasmuch as the molecular weights of volatile bodies represent the weights of equal volumes, it is sufficient to take two tubes of equal size, to place in one a substance of well-known molecular weight, as 18 mgr. of water, or better 119.5 mgr. of chloroform, and in the other a quantity of the

substance to be examined equal to its molecular weight in milligrams. These tubes, as in Hofmann's method for vapor-densities, are placed in the same mercury cistern and surrounded with a glass cylinder, into which the vapor of water, or of some substance whose boiling point is higher, may be conducted. If the assumed molecular weight be correct, the mercury will stand at the same level in both tubes; if not, it must be either half or twice the assumed weight, in which case a marked deviation from uniformity will be observed. It is obvious that by this method, all corrections for temperature and pressure, and the tension of the mercury vapor, and all the subsequent calculation, are avoided. The only difficulty seems to lie in the accurate weighing; but, practically, this is no objection, since the weighing of liquids is effected in small bulbs, and it is sufficiently accurate if carried to milligrams. The tubes are calibrated easily by pouring into each of them a weighed quantity of mercury, about equal in volume to that of the vapor to be estimated. If the mercury does not stand at the same height in both, gradually push a glass rod into it in the larger tube until the same level is reached. Mark carefully the point to which the rod is immersed, cut it off at this place, and allow the piece to rise to the top of the mercury in that tube before heating. By using six of these tubes arranged in one cistern and in a convenient frame, the uniformity of vapor tension when molecular weights of different liquids are used, may be excellently well shown as a lecture experiment.—*Ber. Berl. Chem. Ges.*, v, 597, June, 1872. G. F. B.

7. *On the combined action of Heat and Pressure on Paraffin.*—In a second paper on this subject, THORPE and YOUNG give the results of distillation under pressure of 3½ kilos. of paraffin made from shale, which melted at 46° and was composed of C 85.14, H 14.81. About 4 litres of fluid hydrocarbons were obtained, of which 0.3 liter boiled below 100°, 1 liter between 100° and 200°, and 2.7 litres between 200° and 300°. The marsh gas series and the olefine series—no others were present—were separated by means of bromine. Of the former, pentane, hexane, heptane, octane, and nonane were obtained. Of the latter, the brominated derivatives of the corresponding olefines. Paraffin undergoes a similar decomposition to butane and other members of the marsh gas series.—*Ber. Berl. Chem. Ges.*, v, 556, July, 1872. G. F. B.

II. GEOLOGY AND NATURAL HISTORY.

1 *The Eastern Limit of Cretaceous Deposits in Iowa;* by C. A. WHITE, of Iowa City, Iowa. (Read before the Dubuque Meeting of the American Association for the Advancement of Science.)—At the Chicago meeting of this Association, I had the honor to announce the existence of Cretaceous strata in Guthrie county, Iowa, where they rest unconformably upon the Coal measures; the locality being about eighty miles eastward from the Missouri river, and about forty miles west of the city of Des Moines. I

have, subsequently, examined Cretaceous strata in Brown and Redwood counties, in southwestern Minnesota, where they rest unconformably upon rocks of Azoic age. So far as I am aware, these are the most easterly localities in the interior region of North America at which strata of Cretaceous age have been actually observed *in situ*. The first mentioned Cretaceous rocks are referred to the division which, in my report on the Geology of Iowa, I have named the Nisnabotany sandstone, and the latter to the division called the Inoceramus beds, in the same report. All these, as well as all the Cretaceous rocks hitherto know in the interior region, eastward from eastern Nebraska and Dakota, are referred to the "Earlier Cretaceous" of Meek and Hayden.

I have now to announce discoveries of Cretaceous fossils, and fragments of strata containing them, in the drift of Iowa at other points much farther eastward; the collection which has been made at different localities containing specimens which belong to several of the most characteristic types of that period, especially of its later epochs.

During the year 1870 my attention was called to the existence of these fossils in the drift of Howard county, Iowa, by Mr. John T. Smith, of Lime Springs, and a few weeks ago I visited the locality indicated, in company with him. It is found in a railroad cut just northwest of the village, which is less than five miles south of the northern boundary of Iowa. The fossils and fragments of strata are found imbedded in the ordinary compact blueish clay of the unaltered drift, twenty or twenty-five feet beneath the surface of the soil. The collections have not yet been critically studied, but the following statement of the one made at Lime Springs will give a general idea of its character: 1. Squaloid teeth, of the genus *Otodus;* 2, Teeth of *Saurocephalus?;* 3. Bones, teeth and scales of teliost fishes; 4. *Belemnitella;* 5. *Ammonites* (2 species); 6. *Natica??;* 7. *Dentalium;* 8. *Ostrea;* 9. *Inoceramus;* 10. *Leda?;* 11. *Cytherea;* 12. *Corbula.*

Mr. P. McIsaac, of Waterloo, Blackhawk county, Iowa, has lately found a *Belemnitella* in the unaltered drift near that city, in addition to the ammonite he found there a few years ago. The *Belemnitella* is of the same species as those found in Howard county, sixty miles directly northward.

The fish teeth have been submitted, for examination, to my friend Prof. O. H. St. John, who writes me as follows concerning them.

"All the squaloid teeth belong to the genus *Otodus* of Agassiz, and may represent three species, but I suspect they are but so many forms of one species; this relationship can be determined only by examination of a much larger suite of specimens, since the teeth vary so much in shape and size from different portions of the jaws. I have not been able to determine their specific identity, though they are somewhat like *O. appendiculatus* Ag., a form originally made known from the European chalk formation, and with which later Cretaceous and Tertiary teeth from this country

have been identified—I do not presume to say upon what authority. With *some* of the latter your specimens are intimately related, perhaps identical. You have two or three fragments of teeth (one nearly perfect), which probably belong to the same genus as those from the New Jersey Greensand and *later* deposits known as *Saurocephalus*. All these teeth evidently belong to a later epoch than the chalky beds on the Big Sioux river, near Sioux City, the fishes of which have a much stronger resemblance to those from the Chalk of Europe than have the specimens under consideration, while the squaloid teeth among the latter bear the most intimate resemblance to certain forms of *Otodus* from the Cretaceous rocks of Alabama. Hence I conclude your specimens have been derived from deposits of the Later Cretaceous, probably equivalent to the Alabama fish-bearing Cretaceous strata. That they are *very* late Cretaceous forms there can be no doubt, from the fact of their close relationship to teeth found in the Eocene of the Old World. I am not prepared to show how close this relationship is, although the first sight of your little collection strongly suggested their Eocene age."

Although all the specimens forming the subject of this memoir have been found in the drift, they have been found at such localities, and under such circumstances as to leave no doubt in the mind of the writer that the Cretaceous sea once extended as far eastward, between the 42d and 44th parallels of latitude, as the 92d degree of longitude west from Greenwich. This is nearly two hundred miles further eastward than any Cretaceous deposits were ever known to have extended in the interior region of North America at the time I commenced my official examination of the geology of Iowa in 1866. What gives additional interest to these discoveries is the fact that the fossils doubtless belong to a Mesozoic epoch as late as any yet recognized in any part of North America, and much later than that of any Cretaceous strata of Iowa or of the adjacent parts of Nebraska and Dakota hitherto known. It is true the deposition of *late* Cretaceous deposits only, in the region indicated, requires the assumption that a subsidence took place there during that period; but a similar condition of other strata is found in southwestern Minnesota, where the Inoceramus beds, as before stated, rest upon the Azoic rocks, the older Nishnabotany sandstone being absent there, but present about 150 miles to the southwestward.

None of the strata in which these fossils were originally deposited have, as before intimated, been found *in situ*, but fragments of them, and also the material of the drift to which they evidently, in part, gave origin, show that they were soft and friable like most of the Cretaceous rocks of the great interior region. Consequently they were readily disturbed and removed by the forces in operation during the Glacial epoch. While much of the material of these strata was doubtless transported to great distances and its character as such thus obliterated, delicate fossils, as well as soft and friable fragments of the strata, are found embedded in the

gravelly clay so slightly eroded as to forbid the belief that they have been transported to any considerable distance from the place of their origin.

The fragments of strata referred to have been recognized, so far, only at Lime Springs, but their presence there, as well as the condition in which they are found, inspires the confident hope that we may yet find some of these Cretaceous strata *in situ* in that vicinity.

These discoveries also suggest that we should scan more closely than ever before, not only the character and contents of the drift of central and eastern Iowa, bnt also some of the strata of the same regions, especially sandstones, to determine with certainty whether some of them may not be of Mesozoic age.

2. *On Actual Glaciers in California;* by JOHN MUIR.—On one of the yellow days of October, 1871, when I was among the mountains of the "Merced group," following the foot-prints of the ancient glaciers that once flowed grandly from their ample fountains, reading what I could of their history as written in moraines, cañons, lakes, and carved rocks, I came upon a small stream that was carrying mud of a kind I had never seen. In a calm place, where the stream widened, I collected some of this mud, and observed that it was entirely mineral in composition, and fine as flour, like the mud from a fine-grit grindstone. Before I had time to reason, I said, "Glacier mud—mountain meal!"

Then I observed that this muddy stream issued from a bank of fresh quarried stones and dirt, that was sixty or seventy feet in height. This I at once took to be a moraine. In climbing to the top of it, I was struck with the steepness of its slope, and with its raw, unsettled, plantless, new born appearance. The slightest touch started blocks of red and black slate, followed by a rattling train of smaller stones and sand, and a crowd of dry dust of mud, the whole moraine being as free from lichens and weather-stains as if dug from the mountain that very day.

When I had scrambled to the top of the moraine, I saw what seemed to be a huge snow-bank, four or five hundred yards in length, by half a mile in width. Imbedded in its stained and furrowed surface were stones and dirt like that of which the moraine was built. Dirt-stained lines curved across the snow-bank from side to side, and when I observed that these curved lines coincided with the curved moraine, and that the stones and dirt were most abundant near the bottom of the bank, I shouted "*A living glacier!*"

These bent dirt-lines show that the ice is following in its different parts with unequal velocity, and these imbedded stones are journeying down, to be built into the moraine, and they gradually become more abundant as they approach the moraine, because there the motion is slower.

On traversing my new-found glacier, I came to a crevasse, down a wide and jagged portion of which I succeeded in making my way, and discovered that my so-called snow-bank was clear, green

ice, and, comparing the form of the basin which it occupied with similar adjacent basins that were empty, I was led to the opinion that this glacier was several hundred feet in depth.

Then I went to the "snow-banks" of Mts. Lyell and McClure, and, on examination, was convinced that they also were true glaciers, and that a dozen other snow-banks seen from the summit of Mt. Lyell, crouching in shadow, were glaciers, living as any in the world, and busily engaged in completing that vast work of mountain-making accomplished by their giant relations now dead, which united and continuous, covered all the range from summit to sea.

But, although I was myself thus fully satisfied concerning the real nature of these ice masses, I found that my friends regarded my deductions and statements with distrust; therefore, I determined to collect proofs of the common, measured, arithmetical kind.

On the twenty-first of August last, I planted five stakes in the glacier of Mt. McClure, which is situated east of Yosemite Valley, near the summit of the range. Four of these stakes were extended across the glacier, in a straight line, from the east side to a point near the middle of the glacier. The first stake was planted about twenty-five yards from the east bank of the glacier; the second, ninety-four yards; the third, 152, and the fourth, 225 yards. The positions of these stakes were determined by sighting across from bank to bank, past a plumb-line, made of a stone and a black horse-hair.

On observing my stakes on the sixth of October, or in forty-six days after being planted, I found that stake No. 1, had been carried down stream eleven inches; No. 2, eighteen inches; No. 3, thirty-four, and No. 4, forty-seven inches. As stake No. 4 was near the middle of the glacier, perhaps it was not far from the point of maximum velocity—forty-seven inches in forty-six days, or one inch per day. Stake No. 5 was planted about midway between the head of the glacier and stake No. 4. Its motion I found to be, in forty-six days, forty inches. Thus these ice-masses are seen to possess the true glacial motion. Their surfaces are striped with bent dirt-bands, and are bulged and undulated by inequalities in the bottom of their basins, causing an upward and downward swegding, corresponding to the horizontals wedging as indicated by the curved dirt-bands.

The Mt. Mc Clure glacier is about one-half of a mile in length, and the same in width at the broadest place. It is crevassed on the south-east corner. The crevasse runs about south-west and north-east, and is several hundred yards in length. It is nowhere more than one foot in width.

The Mt. Lyell glacier, separated from that of McClure by a narrow crest, is about a mile in length. I have planted stakes in the glaciers of "Red Mountain," also, but have not yet observed them.

The Sierras adjacent to the Yosemite Valley are composed of slate and granite, set on edge at right angles to the direction of

the range, or about north 30 deg. east, and south 30 deg. west. Lines of cleavage cross these, running nearly parallel with the main range; and the granite of this region has a horizontal cleavage or stratification. The first mentioned of these lines have the fullest development, and give direction and character to many valleys and cañons, and determine the principal features of many rock forms. No matter how hard, how domed or homogeneous the granite may be, it still possesses these lines of cleavage, which require only simple conditions of moisture, time, etc., for their development. But I am not ready to discuss the origin of these planes of cleavage, which make this granite so easily denuable, nor their full significance with regard to mountain structure in general. I will only say here, that oftentimes the granite contained between two of these north 30 deg. east planes is softer than the rock outside, and has been denuded, leaving vertical walls, as determined by the direction of the cleavage, thus giving rise to those narrow-slotted cañons, called "devil's lanes," "devil's gateways," etc.

In many places, in the higher portion of the Sierras, these slotted cañons are filled with snow, which I thought might prove to be ice; might prove to be living glaciers, still engaged in cutting into the mountains, like endless saws. To decide this question, on the 23d of August last, I set two stakes in the narrow-slot glacier of Mt. Hoffman, marking their position by sighting across from wall to wall, as I did on the McClure glacier; but on visiting them, a month afterward, they had been melted out, and I was unable to decide anything with any great degree of accuracy.

On the 4th of October last, I stretched a small trout line across the glacier, fastening both ends in the solid banks which at this place were only sixteen feet apart. I set a short, inflexible stake in the ice, so as just to touch the tightly-drawn line, by which means I was enabled to measure the flow of the glacier with great exactness. Examining the stake in twenty-four hours after setting it, I found that it had been carried down about three-sixteenths of an inch. At the end of four days, I again examined, and found that the whole downward motion was thirteen-sixteenths of an inch, showing that the flow of this glacier was perfectly regular.

In accounting for those narrow-lane cañons, so common here, I always referred them to ice-action in connection with special conditions of cleavage, and I was gratified to find that their formation was still going on. This Hoffman glacier is about 1,000 feet long by fifteen to thirty feet wide, and perhaps 100 feet deep in the deepest places.

I go back to the mountains to complete these observations. These are the first fruits, and the rest of the crop I will bring in when I come to study in the Coast Range. — *Overland Monthly for December.*

3. *Return of the Yale College Geological Expedition.*—Professor Marsh and party returned on the 7th of December from the Rocky

Mountains, where they ha e spent the last two months in geological researches. They bring back a large number of vertebrate fossils from the Cretaceous and Tertiary formations of the West, including many new and interesting Mammals, Birds and Reptiles. Among the treasures secured during the present trip was a nearly entire skeleton of *Hesperornis regalis* Marsh, the gigantic diving bird of the Cretaceous; a second species of *Ichthyornis* (*I. celer* Marsh), and numerous remains of Pterodactyls. The new fossils will soon be described by Professor Marsh.

4. *On Spontaneous fission? in Zaphrentis.*—(Communicated to this Journal).—Among the specimens of *Z. spinulifera* Hall, collected from the St. Louis limestone in Marion County, Iowa, is one showing what is probably true spontaneous fission. This is the only specimen showing such a character, among thousands of specimens of many species, which I have collected from the Palaozoic rocks of America, and seems remarkable in a genus so distinctively, simple and solitary. The outline of the specimen is such as to faintly suggest that its peculiarity may be the result of a fusion of two individuals, but not only is there no limiting wall dividing it into two parts, there is also no impression or suture of the epitheca to suggest such a fusion. The specimen is of ordinary height, the outline of the double calyx being oblong, one diameter being about twice as great as the other. There are two well marked septal fossettes, forming an angle of about 130 degrees with each other, and the other parts are developed in the ordinary way, the transverse plates being common to both parts.

The peculiar form of this specimen is evidently not the result of violence, because the epitheca and transverse plates are unbroken. Specimens showing complete recovery from violence, inflicted while the polyp was living, are not uncommon.

Iowa State University, Aug. 7th, 1872. C. A. WHITE.

5. *Volcano of Kilauea.*—From one of our residents who has just returned from Kilauea by the *Annie*, we learn that the crater is very active. The old South Lake is full and running over in two broad streams, one to the south and the other to the west. A number of beautiful cones were in action, and sending up continuous jets of lava. Mr. Jones, the proprietor of the Volcano house, describes the scene as finer than any he has seen for years. During the last two weeks a number of slight earthquake shocks have been felt at Kapapala, and on Oct. 13th a very heavy one was felt at Hilo—the heaviest that has been felt since the great shock of April, 1868.—*Hawaiian Gazette, Oct.* 27.

6. *The Physical Geology and Geography of Great Britain;* by A. C. RAMSAY, LL.D., F.R.S., Director-General of the Geological Surveys of the United Kingdom. 3d edition, 350 pp. 12mo. With a geolocical map printed in colors. London. (Edward Stanford.)—It is not surprising that Prof. Ramsay's Physical Geology and Geography of Great Britain should have great popularity at home. And it also may well have in this country. For British facts do not belong to Britain, but to

the world, and illustrate universal principles. The general subjects of the origin and arrangements of rocks, and their upturnings and metamorphism; the origin of mountains and valleys and the general features of the surface; and the action of water in the condition of oceans, rivers and glaciers, are treated with a clearness and simplicity calculated to attract the popular reader. The succession of life on the globe is only touched upon briefly with reference to important general truths. But the facts connected with the more recent life in Britain, especially that of the cave animals, and of other Quaternary deposits in which occur traces of man along with bones of extinct quadrupeds, occupy the principal parts of two chapters; and in connection, such subjects as the separation of Britain from the continent, the origin of various rivers, valleys, river terraces and raised beaches, the influence of changes of level on the features and courses of rivers of Britain and France, the qualities of river waters and the nature of British soils, come in for consideration. The work closes with a chapter on the relation of the different races of men in Britain to the geology of the country; and another on the industrial products of the geological formations of Britain, the quantities of available coal in the coal-fields, and the probability of finding other coal-fields beneath the more recent formations. Most of the subjects are illustrated by new facts and views drawn by the author from his own extensive observations, and the volume is thereby rendered a work of great importance to all geologists. Its value is much enhanced by a geological map of Great Britain beautifully colored, which forms its frontispiece.

7. *Elemente der Geologie*, von Dr. HERMANN CREDNER, Professor an der Universität Leipzig. 538 pp. with 380 woodcuts. Leipzig, 1872. Wilhelm Engelmann).—Dr. Credner's work is a well arranged and well illustrated brief manual of geology. The author, some years since, spent considerable time on this continent making geological observations, and has drawn his illustrations more from American facts than is common with German treatises. We think there is much that is hypothetical in his views on the American Huronian, but in general his remarks on American geology are trustworthy.

8. *Lithologie des Mers;* by M. ACHILLE DELESSE.—The publication of the maps of Delesse's new work has already been noticed in this Journal. The text has recently appeared. The author considers in succession the lakes and seas of the world, describes the nature of the bottom and shores, gives lists of the species characterizing them, and found along their coasts, and points out the geological bearing of these and other facts connected with this subject. Delesse has here taken the initial step in an important department of geological science, and has gathered together a large number of facts of interest. At the same time the work shows us how little we know with regard to this great subject. Some additional facts might have been introduced with reference

to the bed of the deep ocean; but the ocean's bottom is still to a great extent an unknown region, and much more investigation will be required before the facts connected with the inland waters of the continents can be properly systematized. Delesse by his labors has given increased interest to these investigations.

9. *Notice of a new Species of Ichthyornis;* by O. C. MARSH.—A second species of the peculiar genus of Cretaceous birds, with biconcave vertebræ (*Ichthyornis*), was found by the writer during a recent visit to Western Kansas. The remains indicate a bird rather larger than *Ichthyornis dispar* Marsh, but of more slender proportions. It may readily be distinguished from that species by the sacrum, which is proportionally more elongated, and has the cup of the posterior vertebral face more deeply concave. This species may be called *Ichthyornis celer*, and the group of birds now represented by the two species may be named *Ichthyornidæ*.

Yale College, Dec. 16th, 1872.

10. *Recherche de la Rapidité de Croissance des Bancs de Coraux dans l' Ocean Pacifique; Expérience faite à l'île de Taïti, en Novembre*, 1869; par MM. F. LE CLERC, Lieutenant de vaisseau, et DUHIL DE BÉNAZÉ, Ingenieur des constructions navales, pp. 22, 8vo. Paris, 1872. (Adolphe Lainé, rue des Saints-Pères, 19).—After some general observations of interest, the authors of this pamphlet give an account of their attempt to ascertain the rate of growth of the coral reef at Tahiti, called the Dolphin Shoal, by measurements from the level of the stone planted on the shore on Point Venus, by Capt. Wilkes, and comparing their results with his. They made measurements: but they observe that Wilkes does not state whether he measured from the top of a head of coral or from the solid bank on which the corals were growing, and further, that the use of an "excellent spirit level," from a stone of so little length, is not sufficiently exact for correct results. Hence, they draw no conclusion from their results. Before leaving the region, they made the following arrangements with reference to future measurements. They planted two blocks of coral, cementing them below and nearly burying them in the soil, placing them 0·21 meters above the Wilkes stone which is between them; they then put a mark upon them on plates of metal, directed toward the place of observation on the shoal. A third stone was placed 40 meters from the southwest angle of the Point Venus lighthouse, in order to give a second observation on the position of the spot on which soundings were to be made. This spot was found to bear from the two new stones N. 77° 30′ E.; from the third stone N. 70° 55′ E.; from the bell of the new mission church S. 81° 40′ E. A horizontal line passing from the mark on the new stone is $7{\cdot}460^{m}$ above the madreporic heads. This observation they leave for comparison with future measurements. They observe that the principal coral of the bank is the *Madrepora plantaginea*. They farther made observations that satisfied them that Tahiti was not at present undergoing any general elevation. Two maps accompany the pamphlet; one is copied from Wilkes; the other is from a chart by MM. Le Clerc and Minier, lieutenants of

the vessel, and contains lines showing the position of the points referred to above.

11. *Brongniart on the theoretical Structure of the Cone in Coniferæ.*—This latest view of the nature of the fertile scale was brought out by Mr. Brongniart, at a meeting of the Botanical Society of France, July 14, 1871, upon the occasion of the reading of the characters of several New Caledonian Araucarias described by the late Mr. Gris and himself. It is, in brief, that the scale and the subtending tract in *Abietineæ* are the result of a complete antero-posterior deduplication in *Pinus*, &c., and incomplete in *Araucaria*, of the same organ which in *Cupressineæ* is undivided or simple. The ovuliferous scale is therefore to the tract what the scale upon the petal of a Crowfoot is to the petal itself.— *Vid. Bull. Soc. Bot. Fr.*, xviii, p. 141. A. G.

12. *Zizania aquatica not tuberiferous.*—In the number of this Journal for August last, p. 151, apropos to *kau-sun* as a product of *Hydropyrum latifolium* and to the suggestion that our Water Rice (*Zizania aquatica*) might bear similar thickened shoots, tubers, or rootstocks, it may be well to mention that our esteemed correspondent, Mr. Lapham, of Milwaukee, has settled the question in the negative. It proves, from his observations and the specimens which he communicates, that our Water Rice has annual roots (as generally supposed) and no radical shoots of any sort. A. G.

13. *The Calcareous-encrusted Charæ* make wretched herbarium-specimens, as is well known, being not only unsightly but usually very fragile. Mr. Corum (vide Bull. Soc. Bot. Fr., xvii, p. 153) remedies this by plunging the fresh specimens for a short time in water containing one per cent. of hydrochloric acid, and afterward washing in pure water. Their aspect when thus prepared and dried is nearly that of the living plant. A. G.

14. *Origin of the Weeping Willow.*—From the investigations of Karl Koch it appears that the "*Garab*," upon which according to the Psalmist, the captive Jews at Babylon hung their harps, is not the weeping willow named *Salix Babylonica* by Linnæus in view of the current tradition, and is not a willow at all, but a poplar. Indeed Ranwolf had long ago concluded that it was not a willow. And the *Salix Babylonica*, the hardiness of which attests a cooler climate than that of Mesopotamia, is now regarded as of Chinese or Japanese origin; so that its Linnæan specific name gives place to that of *Salix pendula* Mœnch.

III. Astronomy.

1. *On the Spectrum of the great Nebula in Orion, and on the motions of some Stars toward and from the Earth.*—In this paper Dr. Huggins gives the results of his recent observations.

Spectrum of the Nebula of Orion.—"Four lines are seen . . . . *First line* . . . . the slit being made very narrow, this line was seen to be very narrow, of a width corresponding to the slit, and defined at both edges, and undoubtedly not double. The line of

nitrogen when compared with it appeared double, and each component nebulous and broader than the line of the nebula. This latter line was seen on several nights to be apparently coincident with the middle of the less refrangible line of the double line of nitrogen. This observation was on one night confirmed by observation with the more powerful spectroscope. . . . . I have not yet been able to find a condition of luminous nitrogen in which the line has the same characters as those presented by the line in the nebula, when it is single and of the width of the slit. . . . . Upon the whole, I am inclined to regard the line in the nebula as probably due to nitrogen.

"*Second line.* This line was found by my former comparisons to be a little less refrangible than a strong line in the spectrum of barium. These sets of measures give for this line a wave-length of 4957 on Angström's scale; this would show that the line agrees nearly in position with a strong line of iron. At present I am not able to suggest to what substance this line belongs. . . . . This line is also narrow and defined. I suspect that the brightness of this line relatively to the first line varies in different nebulæ.

"*Third and fourth lines.** My former observations show that these lines agree in position with two lines of the spectrum of hydrogen, that at F and the line near G. These lines are very narrow and are defined. . . . I have not been able to obtain decisive observations as to the possible motion of the nebula in the line of sight.

In his paper Dr. Huggins gives the details of his observations on various stars, and the following are his results tabulated.

TABLE I.—*Stars moving from the Sun.*

Star.	Compared with	Apparent motion in miles.	Earth's motion.	Motion from Sun.
Sirius,	H	26 to 36	—10 to 14	18 to 22
Betelgeux,	Na	37	—15	22
Rigel,	H	30	—15	15
Castor.	H	40 to 45	—17	23 to 28
Regulus,	H	30 to 35	—18	12 to 17
β Ursæ majoris,	H	------	----	------
γ " "	H	------	----	------
δ " "	H	30	—9 to 13	17 to 21
ϵ " "	H	------	----	------
ζ " "	H	------	----	------
β Leonis,	H	------	----	------
δ "	H	------	----	------
η Ursæ majoris,	H	------	----	------
α Virginis,	H	------	----	------
α Coronæ borealis,	H	------	----	------
Procyon,	H	------	----	-----
Capella,	H	------	----	------
Aldebaran?	Mg	------	----	------
γ Cassiopeiæ,	H	------	----	------

* Dr. Huggins was anticipated in his observation of this *fourth line* by Lieut. J. Herschel and by Prof. J. Winlock, who independently discovered it; the first on the night of Oct. 25, 1868, at Bangalore, India, the second, with perfect distinctness, at Harvard Observatory on the night of Nov. 13, 1868. Mr. Huggins was informed as to the previous observation of Prof. Winlock, but does not mention it in his paper.—A. M. M.

TABLE II.—*Stars approaching the Sun.*

Star.	Compared with	Apparent motion in miles.	Earth's Motion.	Motion toward Sun.
Arcturus,	Mg	50	+5	55
Vega,	H	40 to 50	+3·9	44 to 54
α Cygni,	H	30	+9	39
Pollux,	Mg	32	+17	49
α Ursæ majoris,	Mg	35 to 50	+11	46 to 60
γ Leonis,	Mg	------	----	------
ε Boötis,	Mg	------	----	------
γ Cygni,	H	------	----	------
α Pegasi,	H	------	----	------
γ Pegasi?	H	------	----	------
α Andromeda,	H	------	----	------

On the above determinations Dr. Huggins makes the following remarks:—

"The velocities of approach and of recession which have been assigned to the stars in this paper represent the whole of the motion in the line of sight which exists between them and the sun. As we know that the sun is moving in space, a certain part of these observed velocities must be due to solar motion. I have not attempted to make this correction, because, though the direction of the sun's motion seems to be satisfactorily ascertained, any estimate that can be made at present of the actual velocity with which he is advancing must rest upon suppositions, more or less arbitrary, of the average distance of stars of different magnitudes. It seems not improbable that this part of the stars' motions may be larger than would result from Otto Struve's calculations, which give, on the supposition that the average parallax of a star of the first magnitude is equal to 0″·209, a velocity but little greater than one-fourth of the earth's annual motion in its orbit.

"It will be observed that, speaking generally, the stars which the spectroscope shows to be moving from the earth (Sirius, Betelgeux, Rigel, Procyon) are situated in a part of the heavens opposite to Hercules, toward which the sun is advancing, while the stars in the neighborhood of this region, as Arcturus, Vega, α Cygni, show a motion of approach. There are in the stars already observed exceptions to this general statement; and there are some other considerations which appear to show that the sun's motion in space is not the only or even, in all cases, as it may be found, the chief cause of the observed proper motions of the stars.

"There can be little doubt but that in the observed stellar movements we have to do with two other independent motions—namely, a movement common to certain groups of stars, and also a motion peculiar to each star.

"Mr. Proctor has brought to light strong evidence in favor of the drift of the stars in groups, having a community of motion, by his graphical investigation of the proper motions of all the stars in the catalogues of Mr. Main and Mr. Stone. The probability of all the stars being collected into systems was early suggested by Michell and the elder Herschel. One of the most remarkable instances pointed out by Mr. Proctor are the stars β, γ, δ, ε, ζ, of the Great Bear, which have a community of

proper motions, while α and η of the same constellation have a proper motion in the opposite direction. Now, the spectroscopic observations show that the stars β, γ, δ, ε, ζ, have also a common motion of recession, while the star α is approaching the earth. The star η, indeed, appears to be moving from us, but it is too far from α to be regarded as a companion of that star.

"Although it was not to be expected that a concurrence would always be found between the proper motions which indicate the apparent motions at right angles to the line of sight and the radial motions as discovered by the spectroscope, still it is interesting to remark that in the case of the stars Castor and Pollux, one of which is approaching and the other receding, their proper motions are also different in direction and in amount; and further, that γ Leonis, which has an opposite radial motion to α and β of the same constellation, differs from these stars in the direction of its proper motion."—*Proc. R. S. of L.*, vol. xx, No. 136. A. M. M.

IV. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The following is a list of papers read at the meeting of the National Academy of Sciences, held at Cambridge, Nov. 20, 1872:

1. The organization of the Museum of Comparative Zoölogy in Cambridge; by *L. Agassiz.*
2. On three different modes of teething among Selachians; by *L. Agassiz.*
3. On the manufacture of Gunpowder for great guns, and on increasing the efficiency of small arms by improved ammunition and sights; by *M. C. Meigs.*
4. An Acoustic Pyrometer; by *Alfred M. Mayer.*
5. Results of the Coast Survey astronomical expedition to the Rocky Mountains; by *Chas. A. Young.*
6. Presentation of an isothermal chart and of a hypsometric sketch of the United States; by *Chas. A. Schott.*
7. Account of the proceedings of the International Standards Commission at Paris, September, 1872; by *J. E. Hilgard.*
8. Development of Actiniae; by *Alex. Agassiz.*
9. The glacial phenomena of the Southern hemisphere compared with those of the North; by *L. Agassiz.*
10. Affinities of Echinoderms and Worms; by *A. Agassiz.*
11. On the construction and advantages of a large Aneroid barometer; by *M. C. Meigs.*
12. Notice of investigations making in California on the reliability of the barometer as a hypsometric instrument; by *J. D. Whitney.*
13. Pedicillariae of Echinoderms; by *A. Agassiz.*
14. On the determination of the relative intensities of sounds, and on the measurement of the powers of various substances to transmit and reflect sonorous vibrations; by *A. M. Mayer.*
15. Experimental Exhibition of the exploration of an Acoustic Wave Surface; by *A. M. Mayer.*
16. Researches on the change of dimensions of Iron and Steel rods and of hollow iron cylinders by their magnetization; by *A. M. Mayer.*
17. Analytical Notices; by *W. Gibbs.*
18. Results of recent dredgings on the coast of New England; by *A. E. Verrill.*
19. Tidal Researches; by *W. Ferrel.*
20. Embryological fragments concerning the Volutidae; by *L. Agassiz.*
21. On the specific identity of some animals along the Atlantic and Pacific shores of America; by *L. Agassiz.*
22. The copulatory organs of the Selachians compared with one another and with those of other Vertebrates; by *L. Agassiz.*

23. On the changes Selachians undergo with age; by *L. Agassiz.*
24. Critical remarks about scientific views entertained upon theoretical grounds; by *L. Agassiz.*
25. Observations on the nature and duration of lightning; by *O. N. Rood.*
26. Notice of the progress of the topographical work of the Geological Survey of California; by *J. D. Whitney.*
27. The 1474 Corona line; by *C. A. Young.*
28. Mathematical reversal and semi-reversal; by *Benjamin Peirce.*

2. *Discovery of Mastodon remains in Ohio;* by L. E. HICKS, Prof. of Nat. Sci. (Communicated.)—Mr. C. W. Bryant, engineer on the route of the Atlantic and Lake Erie R. R., has submitted to me for examination a large mammalian bone. I find it to be the left side of the pubic arch of the pelvis of a *mastodon.* Dimensions as follows: Length, 29·5 centimeters; breadth at inner end 16 centimeters; breadth at outer end 14·5 centimeters; thickness in center 9 centimeters. It was discovered in the bank of Raccoon creek, near Granville. The fractured ends are much eroded, and the whole specimen has the appearance of having been rolled and worn by running water before it was deposited in its matrix of clay and gravel. Portions of the matrix adhere firmly, and there is also a partial coating of iron oxide. The specific gravity is greater than that of fresh bone.

Granville, O., Dec. 6, 1872.

3. *Niagara: Its History and Geology, Incidents and Poetry, with Illustrations;* by GEO. W. HOLLEY. 165 pp. 12mo, with a map: 1872. New York City. Sheldon & Co.—Mr. Holley has resided for over thirty years at Niagara Falls, and in the little volume he has lately given us, he records his own observations and the curious facts of various sorts which he has collected about the great cataract. The chapters on the topography and geology of this region are particularly interesting. From the surveys of Capt. Williams for a canal around Niagara Falls and from other sources, he compiles a comprehensive and clear statement of the barrier which formed the eastern margin of Lake Michigan when that lake must have been the largest body of fresh water on the globe, before there was a Niagara and when Lakes Huron, St. Clair and Erie were only portions of the greater Michigan, whose waters form their outlet by the Illinois valley into the Gulf of Mexico. These facts as well as the details of the Niagara section, its retrocession and surrounding phenomena, are familiar to all students of American geology. But to the tourist and general reader the volume of Mr. Holley, which is a free-will offering from an enthusiastic lover of natural scenery, and of this grand passage in nature in particular, will be an acceptable addition to a department of literature in which, as yet, so little has been done in this country. The pleasure of the reader is often marred by faults of style, ambitious efforts at fine writing, which add neither to clearness or accuracy, which, with other minor blemishes, a little judicious pruning would remove.

4. *Photographs of the Hot Springs, Geysers and Scenery in the Region of the Yellowstone National Park,* illustrating the Geologi-

cal Survey of the Territories under the Department of the Interior. —Dr. Hayden's expedition, through the labors of Mr. W. H. Jackson, of Washington City, the photographer, has added to the photographs of 1871 an extended series of pictures of the wonderful objects seen during the past summer. Next to a personal visit to this land of geysers, hot springs, fountains of boiling mud, waterfalls, lakes and majestic mountains, is a morning spent over these photographs. They would do credit to the best photographic laboratory, and considering the difficulties inherent in a long and arduous journey, they are really admirable.

The Yellowstone series well illustrates the advantage of photography over any hand drawings in bringing out details of structure, especially where the artist is guided by the geologist in selecting the best points of view. Among the novelties which are a positive addition to our knowlege of orography we mention particularly the views of the Three Tetons. Among the Geyser views there are two of "Old Faithful" in full action, which are exceedingly effective; others of basins and cones in which the varied tracery of the surface may be studied with much of the satisfaction to be had from actual examination; others of long cascade slopes which have been gracefully terraced by the mineral depositions of the waters, and whose basins, brimfull to their delicate edges with the petrifying waters, reflect mirror-like the surrounding objects; others showing large areas of the Geyser region with the geysers in action. Such views give an opportunity for the geologist to compare beds of chemical deposition with our ordinary limestones.

There are already 600 of these views, and the Government has given permission to have them sold at moderate prices. There are three series of sizes, one 11×14 inches at $1 each, a medium size, 8×10 at 50 cts. each, and stereographs at $3 per dozen.

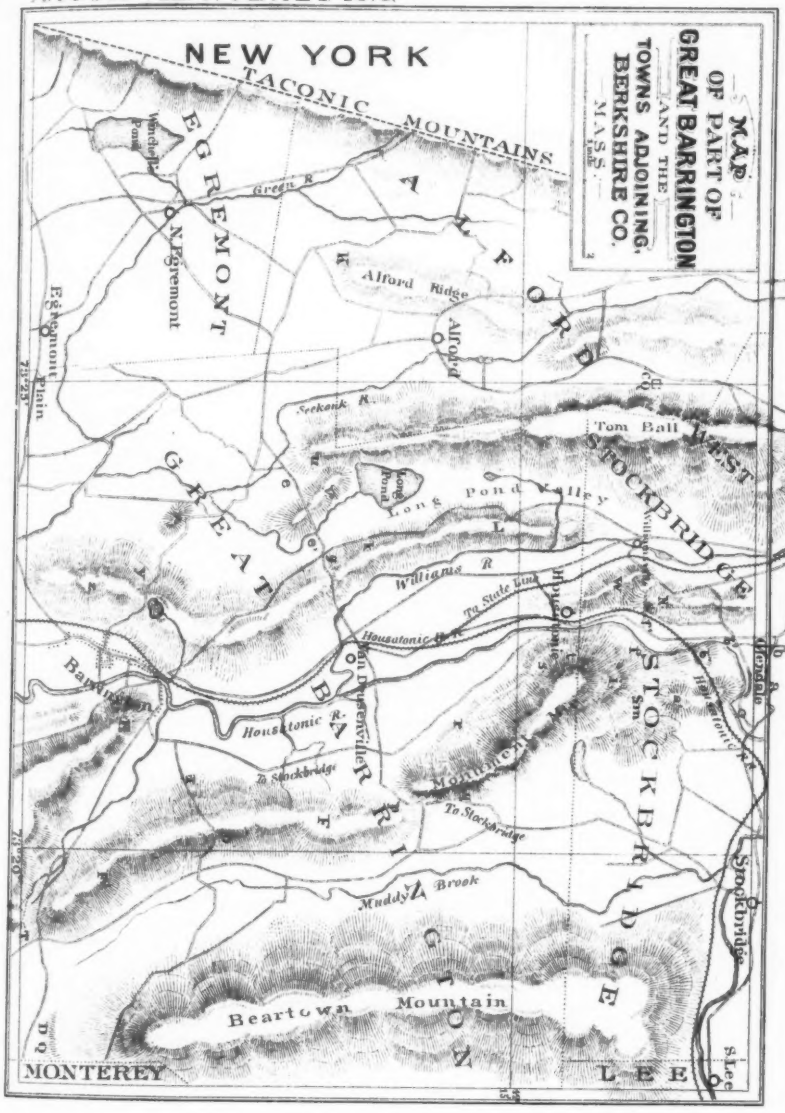
5. *A Popular Treatise on Gems;* by Dr. L. Feuchtwanger. 528 pp. 12mo. New York, 1872 (author, No. 55 Cedar st., New York). With the exception of a brief addition to the Appendix, this is a reprint of the last edition of Feuchtwanger's valuable and well illustrated work on gems.

6. *A Manual of Microscopic Mounting, with notes on the collection and examination of objects;* by John H. Martin, 200 pp. 8vo, with many illustrations drawn by the author. Philadelphia, 1872. (Lindsay & Blakiston). From the London edition.—This work is an exceedingly valuable companion to the student in microscopy. It describes apparatus, methods of mounting and preservation, and methods of examination, with all the fullness of detail required by the practical microscopist. The drawings are numerous and most of them original, and much in the work is new to science.

The Expressions of the Emotions in Man and Animals. By Charles Darwin. 374 pp. 12 mo. London, 1872 (John E. Murray).

Descriptive Catalogue of Minerals, being the Collection of William Nevill, F.G.S. Godalming, Surrey, 1872. pp. 159. London (printed by Taylor & Francis).

The Earth a Great Magnet; by A. M. Mayer, Ph. D., Prof. of Physics in the Stevens Technological Institute of Technology. 284 pp. 12mo, 1872. New Haven: C. C. Chatfield & Co.


MAP
OF PART OF
GREAT BARRINGTON
AND THE
TOWNS ADJOINING,
BERKSHIRE CO.
MASS.
NEW YORK
TACONIC MOUNTAINS
EGREMONT
GREAT BARRINGTON
ALFORD
STOCKBRIDGE
LEE
MONTEREY
Beartown Mountain
Muddy Brook
Green R.
Alford Ridge
Alford
Egremont Plain
Sekonk R.
Tom Ball
Long Pond
Long Pond Valley
Williams R.
Housatonic R.
Housatonic
Monument Mt.
To Stockbridge
Stockbridge
Lee